

EARTHQUAKE INSURANCE: PROBLEMS AND OPTIONS

PRINTED AT THE DIRECTION OF

HON. JOHN C. DANFORTH, *Chairman*

FOR THE USE OF THE

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UNITED STATES SENATE



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LETTER OF TRANSMITTAL

U.S. SENATE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC, December 29, 1986.

DEAR COLLEAGUE: I am pleased to submit for your information and use a report, "Earthquake Insurance: Problems and Options," prepared by the Congressional Research Service at the request of the Committee on Commerce, Science, and Transportation.

This Committee authorized the Earthquake Hazards Reduction Program in the 99th Congress. During the authorization process, this Committee explored the inadequate availability of earthquake insurance and the difficulties of the earthquake insurance and reinsurance industry in providing this coverage. This CRS report provides background information on these problems and offers a variety of recommendations and solutions for Congress to consider.

The Committee hopes this report will contribute to the general debate as the 100th Congress examines the status of the personal and property insurance industry.

Sincerely,

JOHN C. DANFORTH, *Chairman.*

(III)

LETTER OF SUBMITTAL

CONGRESSIONAL RESEARCH SERVICE,
THE LIBRARY OF CONGRESS,
Washington, DC, December 10, 1986.

HON. JOHN C. DANFORTH,
*Chairman, Committee on Commerce, Science, and Transportation, U.S.
Senate, Washington, D.C.*

DEAR MR. CHAIRMAN: In response to your request, we are submitting the enclosed report, "Earthquake Insurance: Problems and Options." The report addresses the twin problems associated with earthquake insurance: the small percentage of people and property insured against earthquakes, and the perceived vulnerability of insurance companies to catastrophic earthquakes. The report provides some basic background on earthquakes and insurance operations, discusses these problems associated with earthquake insurance, and discusses options to address these problems. We hope that the study makes a significant contribution towards understanding these problems.

The study was conducted by David Cheney of our Science Policy Research Division, and David Whiteman of our Economics Division. David Cheney was the primary author of the report and coordinated the project. David Whiteman participated in the design and researching of the project, provided expertise on the structure and operations of the insurance industry, and contributed analytical work that served as the basis for the section of the report on the insurance industry.

We appreciate the opportunity to assist your Committee, and we hope that the study will serve your Committee's needs and those of other committees and Members of Congress.

Sincerely,

JOSEPH E. ROSS, *Director.*

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EXECUTIVE SUMMARY

Earthquakes pose an unusual threat to society because they are rare but catastrophic. Single earthquakes can potentially kill tens of thousands of people and cause more than \$60 billion worth of property damage. Of special concern is the 50 percent probability of a major earthquake in Southern California in the next 30 years. Damaging earthquakes have occurred or could occur in many other parts of the United States, including the Pacific northwest, the Mississippi valley, Alaska, Utah, South Carolina, and New England.

Because they can be so catastrophic, earthquakes could have a severe impact on two of society's main mechanisms for protecting people from such catastrophic losses: insurance and disaster assistance. There are two fundamental earthquake insurance problems: (1) too few people are insured for earthquakes, and thus rely too much on disaster assistance, which is widely viewed for several reasons as an undesirable means for society to cope with disasters; and (2) insurers believe they are too vulnerable to earthquake losses.

These two problems at first glance seem contradictory: the perceived vulnerability of insurers seems at odds with the high number of people who are not insured against earthquakes. But much of the insurance industry's vulnerability to earthquakes comes about through losses under other types of insurance coverage, such as fire and general liability, and most of the liability is from commercial rather than residential insurance.

THE LACK OF INSURANCE COVERAGE

In California, which is believed to have the highest levels of residential earthquake coverage, less than 15 percent of the homeowners choose to buy earthquake insurance. The lack of earthquake insurance for homeowners and small businesses is of public concern because in the absence of insurance, earthquake victims will likely have to rely upon various forms of disaster assistance after an earthquake. There are several widely recognized problems with relying on disaster assistance: (1) it is costly to the Federal Government and taxpayers; (2) it in effect subsidizes disaster losses, and thus provides a disincentive for people to take actions to reduce risks; (3) it does not provide adequate assistance to all victims; (4) it is inequitable; and (5) it does not allow people to choose the amount of protection they desire. Insurance is seen as potentially correcting many of these problems.

Most homeowners do not buy earthquake insurance for several reasons, including: (1) high rates and deductibles; (2) unenthusiastic marketing of earthquake insurance; (3) a traditional reluctance of homeowners to choose insurance to protect themselves unless required to; and (4) a possible belief that the Federal Government will provide assistance after a catastrophic earthquake.

THE VULNERABILITY OF INSURERS

For several reasons, earthquakes pose severe problems for insurers. The problems result from the magnitude of possible losses from earthquakes and the inability of the insurance industry to build adequate reserves for such losses. As described above, total property damage from a catastrophic earthquake could be over \$60 billion, and under some scenarios (such as a catastrophic fire, a dam failure, or a nuclear or chemical accident caused by the earthquake) could be higher still. Non-property losses, such as business interruption could also cause greater economic losses. There is considerable uncertainty in the size of these losses, and only rare earthquakes would cause losses as large as those described above.

There is greater uncertainty in the size of the losses to the insurance industry following a catastrophic earthquake. A lower limit is the \$4-6 billion determined by the California Department of Insurance for earthquake coverage alone. Companies that have examined their potential losses have found that losses under earthquake coverage may be a small part of their total losses in the event of an earthquake. When estimates of losses under other types of coverage (i.e. fire insurance, workers compensation, general liability, etc.) as well as depreciations in investments are included, some insurers estimate that the total losses to the insurance industry could be in the range of \$60 billion. While not everyone believes that losses could be this large, and for most large earthquakes would certainly not be, some insurers are taking the possibility of losses this large quite seriously.

Depending on the actual size of the insured losses in an earthquake, an earthquake could have minor to severe effects on the insurance industry. The insurance industry has only a limited capability to handle rare, large catastrophes: tax laws and accounting practices effectively prevent insurers from building up large reserves for catastrophes, and the world reinsurance market may not be adequate to handle losses above a certain size. Losses of a few billions of dollars could probably be absorbed; losses in the tens of billions might not be, potentially causing widespread insolvencies or at least preventing insurers from being able to meet demands for insurance. The effects of large losses on other parts of the financial system are speculative but possibly serious.

OPTIONS TO ADDRESS THESE PROBLEMS

Many options could address these earthquake insurance problems. Various insurance industry groups have developed proposals and have attempted, with partial success, to develop a consensual industry

proposal. Most proposals are for either a federally backed program for residential coverage, a federally backed excess (reinsurance) program, or a combination of the two. Details have not yet been worked out.

Some of the issues that Congress may wish to consider when deciding what action, if any, to take, include:

- Is Federal involvement needed?
- Should any Federal involvement be as an insurer, a reinsurer, or both?
- Should a program include natural hazards other than earthquakes?
- Should a program be paid for before or after a disaster?
- Should earthquake insurance be voluntary or mandatory?
- Should disaster insurance be subsidized?
- Should hazard reduction requirements accompany an insurance program?

Congressional options could be to: (1) proceed now with hearings and possible legislation; or (2) work to develop better information on potential earthquake losses, the vulnerability of the insurance industry, the costs of alternative insurance programs, and the public acceptability of various programs before taking any further action.

4

Chapter I

INTRODUCTION¹

This report is concerned with the interaction of earthquakes, one of the most catastrophic of all natural hazards, and insurance, one of society's mechanisms for protecting people and businesses from catastrophes. The interaction between earthquakes and insurance is complex and problematic in several ways. This report is intended to explain the complexity of the problems, and to discuss Congressional options to address the problems.

The first problem is that because few homeowners and small businesses are insured for earthquakes, there are likely to be large uninsured damages when the next catastrophic earthquake occurs. The result is that people and communities will have to rely on disaster assistance from various sources, which is likely to be inadequate to repair the losses and is likely to be costly to the Federal Government. The second problem is that for several reasons earthquakes pose severe problems for insurers. In some earthquake scenarios, many insurance companies could become insolvent following a catastrophic earthquake. Some people hypothesize that the failure of some insurance companies, especially when combined with the other disruptive effects of an earthquake on the financial system, could severely disrupt other parts of the financial system.

The two problems are intertwined. Efforts to increase the number of people who purchase earthquake insurance may further increase the vulnerability of the insurance industry, and policies to reduce the vulnerability of the industry could affect earthquake coverage.

These problems are caused by the rare, catastrophic nature of earthquakes and the operating environment and practices of the insurance industry. Earthquakes are more catastrophic than other natural hazards that the United States commonly faces—a single event can cause many thousands of deaths and many billions of dollars of property damages. Other hazards in the United States, including floods, hurricanes and nuclear accidents, have typically resulted in property damages a factor of ten smaller than those expected to result from a catastrophic earthquake. The insurance system, while well equipped to deal with losses that occur consistently from year to year and for which rates can be calculated and charged, is much less prepared to handle rare and catastrophic losses of the magnitudes posed by catastrophic earthquakes. Tax regulations effectively prevent insurance companies from building reserves for rare catastrophes and the international reinsurance market may be unreliable in meeting obligations following a catastrophic earthquake.

See footnotes at end of report, p. 57.

These earthquake insurance problems are not new. While earthquake insurance has been problematic in the United States since it was first offered early in this century, concern about earthquake insurance has recently intensified. This increased awareness and concern has several apparent causes:

- the geologists' estimate of a 50 percent chance of a great earthquake in Southern California in the next 30 years;
- the greater knowledge of the earthquake hazards in the central United States and other parts of the country;
- the September 19, 1985, Mexico City earthquake;
- a general crisis in the commercial insurance marketplace that has intensified earthquake insurance problems, making earthquake insurance less available and affordable;
- an increased awareness of the potential vulnerability of insurance companies and other financial institutions to earthquakes; and
- court rulings that have at times tended to expand or extend the liability of insurance companies to losses they thought were excluded from coverage and for which they did not charge a premium.

As a result of this heightened concern, representatives of insurance companies have been meeting to attempt to agree on a proposal for Federal involvement in earthquake insurance. Earthquake insurance issues have also been raised before Congress.²

Congress may wish to consider what, if anything, to do about the earthquake insurance problems. Should it decide to leave the current system alone? Should it support any of the insurance industry proposals. Should it develop different legislation? Should it support studies to further understand the problems? These are the types of questions for which this report provides background.

This report examines the public policy issues connected with earthquake insurance from a congressional perspective, and provides some essential background information necessary to understand these issues. The report also attempts to identify sources of conflict and areas where further information may be necessary to resolve the issues.

Earthquake insurance issues are closely connected to broader problems with the insurance industry, the tax code, the tort law system, disaster assistance and insurance programs, and natural hazard mitigation programs. Although it is beyond the scope of this report to address all relevant problems in these areas, the report does attempt to point out how these areas are connected to earthquake insurance problems. There is a close connection between earthquake insurance and insurance for other natural hazards; some proposals to address earthquake insurance problems would create programs that would insure many natural hazards. Although this report primarily focuses on earthquake insurance, it addresses the insurance of other natural hazards in order to discuss these proposals.

Chapter II

BACKGROUND

To understand why earthquakes and other natural hazards present special problems for insurance, this chapter provides some basic background on earthquakes, other natural hazards, and insurance.

BACKGROUND ON EARTHQUAKES AND NATURAL HAZARDS

Earthquakes are difficult to insure because they can cause losses in the tens of billions of dollars and occur sporadically and unpredictably. Other natural hazards can pose similar problems for insurers. Characteristics of earthquakes and other natural hazards that affect their insurability include where and when they occur, the types of damages they cause, the average and largest possible losses they cause, and the predictability of the damages. This section discusses these factors and their connection to disaster insurance.

EARTHQUAKES AND EARTHQUAKE DAMAGE

Magnitude and Intensity

Earthquakes are caused by the sudden movement of rock masses in the upper earth, usually in response to large-scale "tectonic" forces in the earth. Two main scales are used in measuring earthquakes. The *Richter Magnitude* of an earthquake is a measure, on a logarithmic scale, of the energy released by the earthquake. A change of one in magnitude represents a difference of a factor of about 30 in energy released—an earthquake of magnitude 7 releases about 30 times more energy than an earthquake of magnitude 6, and about 900 times more energy than an earthquake of magnitude 5. The *intensity* of an earthquake is a measure of its effects at a given site. The standard scale is the Modified Mercalli Intensity Scale, shown in table 1. The magnitude and intensity of an earthquake are not directly comparable because the magnitude is a property of the earthquake while the intensity describes the earthquake's effects at a particular location. There is, however, a rough correlation between the magnitude of an earthquake and the maximum intensity, shown in figure 1. The amount of damage an earthquake causes is more closely related to the distribution of its ground shaking intensity than to its magnitude.

The damage caused by an earthquake depends on a number of factors, including the magnitude of the earthquake, its proximity to buildings and structures, the local ground and soil characteristics, and the earthquake resistance of the structures in the area. Because all of these factors vary greatly, there is a wide variation in the amount of damage caused by earthquakes. Some earthquakes of great magnitude ($M > 8$) have caused relatively little property damage, while other much smaller earthquakes have caused extensive damage.

TABLE 1.—INTENSITY

INTENSITY

Earthquake intensity is a measure of the effects of an earthquake at a particular place. Intensity is determined from observations of an earthquake's effect on people, structures, and the Earth's surface. The first intensity scale to gain wide use was developed in Europe in 1883 by M.S. DeRossi of Italy and F.G. Forel of Switzerland. The Rossi-Forel Scale grouped earthquake effects into 10 steps of intensity beginning with 1 for the least noticeable. The Rossi-Forel Scale proved too peculiar to 19th century Europe to be universally applicable. In 1902, Giuseppe Mercalli introduced an improved scale which also had 10 grades of intensity (later increased to 12). A modified and condensed version, the Modified Mercalli Intensity Scale (MM), is used extensively in the United States today.

MODIFIED MERCALLI SCALE (ABRIDGED)

I. Not felt except by a very few under especially favorable circumstances. (I Rossi-Forel Scale.)

II. Felt only by a few persons at rest, especially on upper floors of buildings. Delicately suspended objects may swing. (I to III Rossi-Forel Scale.)

III. Felt quite noticeably indoors, especially on upper floors of buildings, but many people do not recognize it as an earthquake. Standing motorcars may rock slightly. Vibration like passing truck. Duration estimated. (III Rossi-Forel Scale.)

IV. During the day felt indoors by many, outdoors by few. At night some awakened. Dishes, windows, and doors disturbed; walls make creaking sound. Sensation like heavy truck striking building. Standing motorcars rocked noticeably. (IV to V Rossi-Forel Scale.)

V. Felt by nearly everyone; many awakened. Some dishes, windows, etc., broken; a few instances of cracked plaster; unstable objects overturned. Disturbance of trees, poles, and other tall objects sometimes noticed. Pendulum clocks may stop. (V to VI Rossi-Forel Scale.)

VI. Felt by all; many frightened and run outdoors. Some heavy furniture moved; a few instances of falling plaster or damaged chimneys. Damage slight. (VI to VII Rossi-Forel Scale.)

VII. Everybody runs outdoors. Damage *negligible* in buildings of good design and construction; *slight to moderate* in well built ordinary structures; *considerable* in poorly built or badly designed structures. Some chimneys broken. Noticed by persons driving motorcars. (VIII Rossi-Forel Scale.)

VIII. Damage *slight* in specially designed structures; *considerable* in ordinary substantial buildings, with partial collapse; *great* in poorly built structures. Panel walls thrown out of frame structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned. Sand and mud ejected in small amounts. Changes in well water. Persons driving motorcars disturbed. (VIII+ to IX Rossi-Forel Scale.)

IX. Damage *considerable* in specially designed structures; well-designed frame structures thrown out of plumb; *great* in substantial buildings, with partial collapse. Buildings shifted off foundations. Ground cracked conspicuously. Underground pipes broken. (IX+ Rossi-Forel Scale.)

X. Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations; ground badly cracked. Rails bent. Landslides considerable from river banks and steep slopes. Shifted sand and mud. Water splashed (slopped) over banks. (X Rossi-Forel Scale.)

XI. Few, if any (masonry) structures remain standing. Bridges destroyed. Broad fissures in ground. Underground pipelines completely out of service. Earth slumps and land slips in soft ground. Rails bent greatly.

XII. Damage *total*. Waves seen on ground surfaces. Lines of sight and level distorted. Objects thrown upward into the air.

Source: Schnell, Mary L. and Darrell G. Herd, eds. National Earthquake Hazards Reduction Program: Overview. Report to the United States Congress. Alexandria, VA, U.S. Geological Survey Circular 918. 1983. p. 24-25.

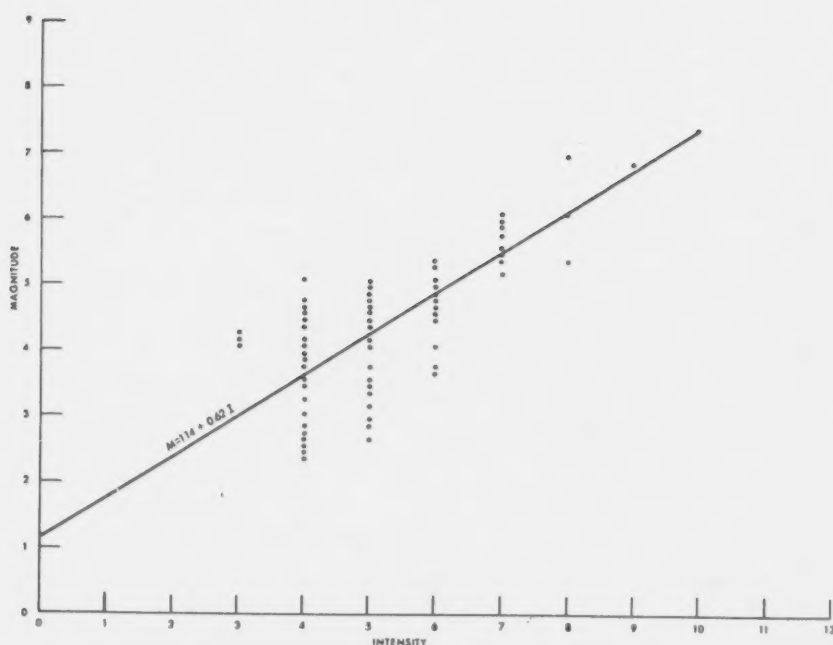


FIGURE 1.—Relationship between magnitude and intensity for California earthquakes.

Source: Algermissen, S.T., J.C. Stepp, W.A. Rinehart, and E.P. Arnold. *Studies in Seismicity and Earthquake Damage Statistics, 1969. Appendix B. Report Prepared for the Department of Housing and Urban Development. U.S. Department of Commerce, Coast and Geodetic Survey. 1969. p. 19.*

Distribution of Earthquakes

Earthquakes are a national problem, but the risks from earthquakes are unevenly distributed. Earthquakes occur throughout much of the United States, but are most frequent in the west. Figure 2 shows occurrences of major U.S. earthquakes. Seismicity is highest on the west coast but 37 states in the United States are in the two highest (out of 4) risk zones. Some 70 million people live in these two highest risk zones. Although the western United States has the most earthquakes, some of the most intense earthquakes have occurred in the east (for the purpose of earthquakes, "east" usually means east of the Rocky Mountains). The 1811-12 earthquakes at New Madrid, MO were the most intense to strike the contiguous United States in recorded history. Severe east coast earthquakes have occurred at Charleston, SC in 1866, and near Boston in 1755. Eastern U.S. earthquakes shake a much larger area than western U.S. earthquakes of the same magnitude (see figure 3); the rock transmits earthquake energy much further. Even though earthquakes are less common in the east than in the west, because eastern earthquakes shake a larger area, the average ground shaking intensity to be expected at eastern sites is close to that expected at west coast sites.

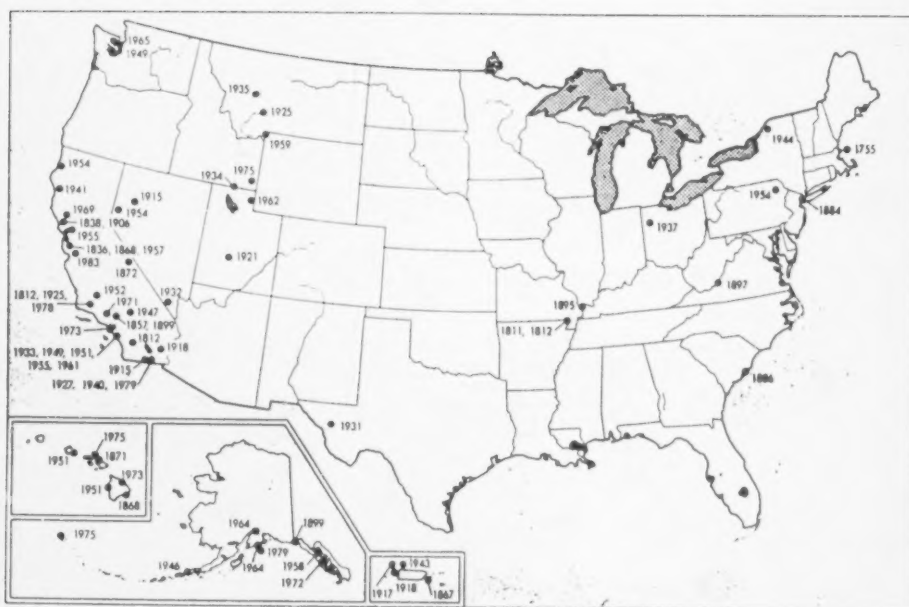


FIGURE 2.—Notable historic damaging earthquakes in the United States.

Source: Schnell, Mary L. and Darrell G. Herd, eds. National Earthquake Hazards Reduction Program: Overview. Report to the United States Congress. Alexandria, VA, U.S. Geological Survey Circular 918. p. 4.

EARTHQUAKES OF SIMILAR MAGNITUDE AFFECT LARGER AREAS IN THE EAST



FIGURE 3.—Earthquakes of Similar Magnitude Affect Larger Areas in the East. Courtesy of the U.S. Geological Survey.

Although earthquakes are a national problem, California is an area of special concern. The concern is largely due to the high frequency of earthquakes in historic time and the predictions of earthquakes in the coming decades. Geologists have made estimates of the probability and likely magnitudes of earthquakes occurring along different segments of the San Andreas fault in the next 30 years, shown in figure 4. The southern San Andreas, where geologists estimate there to be a 50 percent chance of a great ($m > 8$) earthquake occurring in the next 30 years, is the area of most urgent concern.

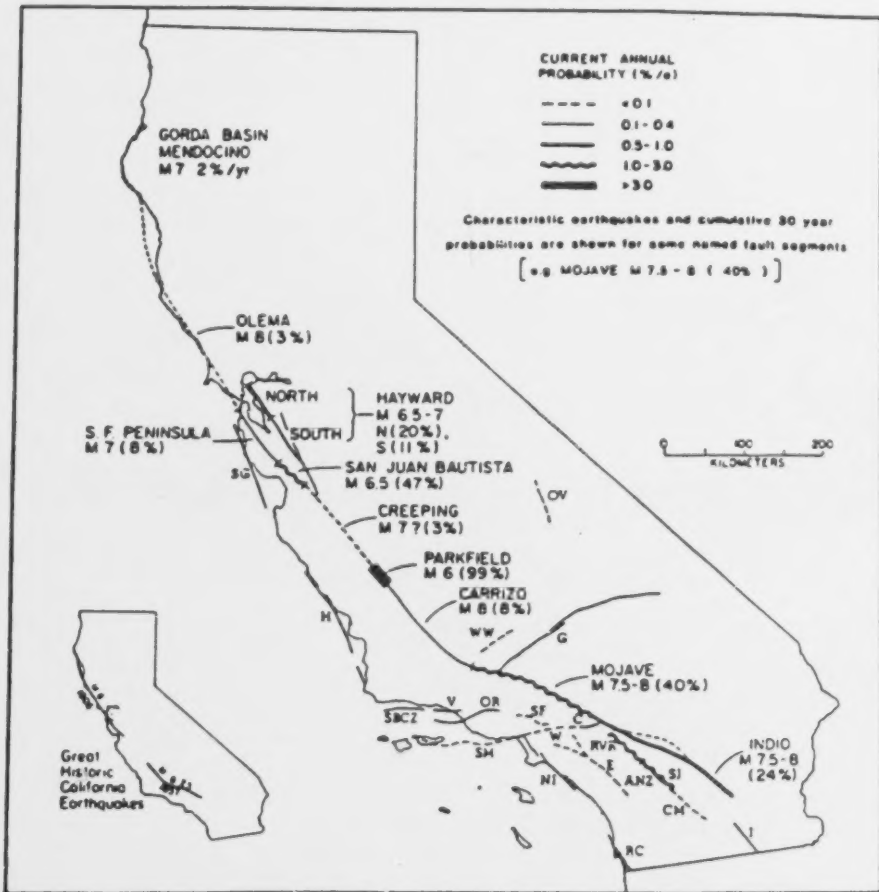


FIGURE 4.—Earthquake Probabilities in California. Courtesy of the U.S. Geological Survey.

Types of Damages from Earthquakes

Earthquakes cause damage through several direct and indirect means. Most earthquake damage results from ground shaking, which literally shakes apart weak buildings. Ground shaking can cause damage over a very large area, sometimes hundreds of miles away from the center of the earthquake. Ground shaking from earthquakes consists of several types of waves with different motions and frequencies, and which have their greatest effect on different types of soil and buildings. In the September 1985 Mexico earthquake, earthquake waves of a certain

frequency resonated with the Mexico City soils and tall buildings. These tall buildings, several hundred miles away from the center of the earthquake, were extensively damaged (see figure 5) even though relatively little damage occurred closer to the center of the earthquake.

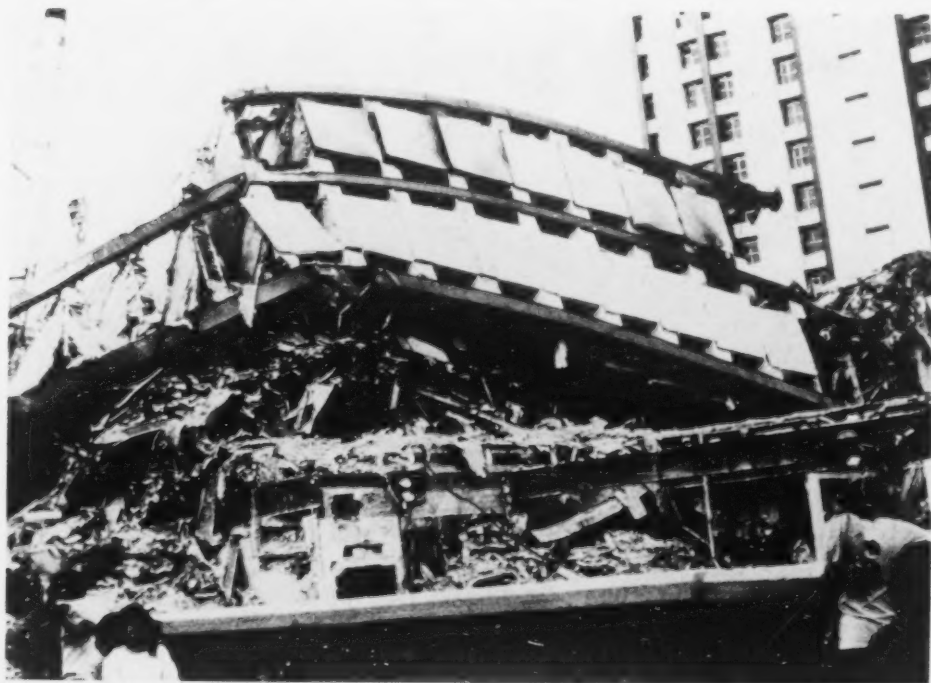


FIGURE 5.—Tall building collapsed due to groundshaking, Mexico City, 1985.
Courtesy of the U.S. Geological Survey.

Earthquakes also cause damage through several other means that can be highly damaging in certain areas but cause less widespread damage than ground shaking. These include surface faulting, landslides, liquefaction, and tsunamis.

Surface faulting occurs when the movement of rock masses in an earthquake reaches the surface. Surface faulting can be very damaging to structures built across faults but because the areas affected by surface faulting are much smaller than those affected by ground shaking, surface faulting does not usually cause a major part of the total damage in earthquakes. Areas damaged by surface faulting are likely to be strongly shaken as well. Damage through surface faulting is more likely in the western than eastern United States, because more of the faults reach the surface.

Landslides, of both rock and mud, can also be very damaging locally. Landslides result from unstable soil and rock on slopes. Landslides occur without earthquakes, but earthquakes often trigger landslides that are ready to happen.

Liquefaction occurs when strong ground shaking causes soils with a

high water content to become liquid. When this happens, buildings built on the unstable soil can topple (see figure 6). Like surface faulting and landslides, liquefaction occurs in identifiable geographic areas and thus the hazard can potentially be avoided through careful land use.

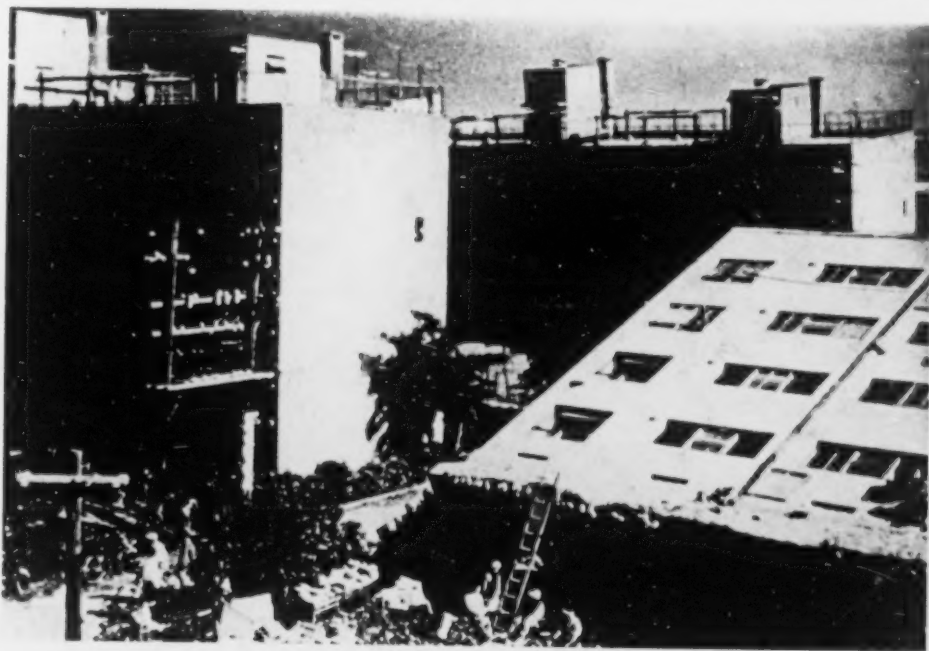


FIGURE 6.—Foundation failure due to soil liquefaction, Niigata, Japan, 1964.
Courtesy of the U.S. Geological Survey.

Tsunamis or *seismic sea waves* are waves in water caused by underwater ground movement. Tsunamis have very long wavelengths—up to 400 miles between wave crests—and travel at speeds from 300 to 600 miles per hour.³ The height of tsunamis may be only one or two feet in deep water, but because the water stacks up when the waves reach a shore, the wave height can increase to tens of feet and can cause extensive damage in coastal regions (see figure 7). Because there is more earthquake activity along the rim of the Pacific than the rim of the Atlantic, tsunamis are more common on the Pacific coast of the United States (including Alaska and Hawaii) than on other U.S. coasts.

In addition to these earthquake-related natural hazards, earthquakes can also cause further damage through their effects on man-made systems. Earthquakes often lead to fires and damage critical facilities. An earthquake can break gas and water mains, both starting fires and making them more difficult to put out. Due to a possible large number of simultaneous fires, damaged roads, and perhaps damaged firefighting equipment, firefighters are less likely to be able to respond to all fires following an earthquake. The extent of fire damage following an earthquake may also depend on the wind conditions. All of these factors make it difficult to predict the extent of fire damage following a major earthquake. Eighty percent of the damage from the 1906 San Francisco earthquake was due to fire.⁴

Earthquakes also threaten such potentially hazardous facilities as dams, nuclear power plants, and chemical plants, and the failure of any of these facilities can cause further loss of life and property damage. Earthquakes can also damage facilities that are needed to reduce loss of life, such as hospitals and fire stations.



FIGURE 7.—Tsunami damage. Courtesy of the U.S. Geological Survey.

The diversity of these modes of damage from earthquakes complicates the insuring of the damages. It is difficult to estimate the damages to be expected from earthquakes and thus difficult for insurance companies to estimate their potential liabilities. Although people may not be insured for earthquakes, earthquakes can cause damage through other means, such as fire, that may be insured. If homes or businesses are insured for fire but not earthquakes, there could, in some cases, be an incentive for arson and a disincentive for property owners to extinguish fires. This could affect the total property damaged in an earthquake and the liabilities of insurance companies.

Earthquake Resistance of Structures

Some types of structures are much more earthquake resistant than others. Following earthquakes, investigators have examined buildings that have fallen and have collected data that allows them to estimate the amount of damage to be expected in different types of buildings from different intensities of ground shaking. The expected damages by building class that the California Department of Insurance uses in estimating the losses to insurance companies due to earthquake shaking from a magnitude 8.25 earthquake are shown in table 2. They indicate the relative earthquake resistance of different types of buildings.

TABLE 2.*

Construction class and simplified description	Probable maximum loss (percent)
1A—Single through four family dwelling	7
1B—"Homeowners"	7
1C—Habitational wood frame and stucco building not exceeding two stories and non-habitational wood frame and stucco less than 3 stories and under 300 sq. ft. ground floor area	8
1D—Other wood frame and stucco buildings	15
1E—Mobile homes	7
2A—One story all metal buildings less than 20,000 sq. ft.	7
2B—Other all metal buildings	15
3A—Different categories of steel frame buildings	20
3B—Different categories of steel frame buildings	30
3C—Different categories of steel frame buildings	35
4A—Different categories of reinforced concrete buildings	25
4B—Different categories of reinforced concrete buildings	35
4C—Different categories of reinforced concrete buildings	50
4D—Different categories of reinforced concrete buildings	45
5A—Reinforced concrete or masonry exterior load bearing walls, and wood frame or reinforced interior walls	30
5B—Buildings with reinforced brick or other solid masonry load-bearing walls	70
5C—Buildings with load-bearing walls of hollow tile or hollow masonry, adobe, or buildings not covered in other classes	85
6—Buildings designed to be earthquake resistant	15
7—Bridges, tunnels, dams, piers, etc.	50

As can be seen from the table, there is a vast difference in the damages expected to different types of buildings from the same intensity of earthquake shaking. Earthquake insurance rates generally reflect these differences between types of buildings, and thus provide some incentive to use safer types of buildings.

Reducing Earthquake Losses

As suggested by the table above, one way of reducing earthquake losses is to replace buildings in the most earthquake-prone categories with buildings that are more earthquake resistant. Other ways to reduce earthquake damage include improving the quality of buildings within each building class, improving land use, making hazardous facilities (such as dams, chemical plants and nuclear power plants) more earthquake resistant, and improving preparedness for and response to earthquakes. Better land use consists of first identifying the earthquake hazards and then siting and building structures appropriate for the hazards. The safety of buildings and hazardous facilities can be improved by using building codes that are appropriate for the degree of seismic hazard, and by removing buildings, such as unreinforced masonry buildings, that are special risks. Research to improve earthquake design and post-earthquake examinations to determine how well designs perform are also essential to making structures more earthquake resistant. Better preparedness and response consists of being prepared to take damage-reducing actions immediately following an earthquake, such as turning off gas and electricity, fighting fires, and providing for emergency medical care. Successful prediction of earthquakes could allow many actions to prevent deaths and property damage, such as shutting down certain hazardous facilities and operations and moving people and valuables out of vulnerable buildings.

In the long run, actions taken to reduce earthquake losses reduce the total costs of earthquakes to society, in contrast with various disaster assistance or insurance systems that primarily redistribute costs among insurers, taxpayers, policy holders, and disaster victims. Therefore, the effects of any insurance system on hazard reduction activities is in the long run one of the most important characteristics of any system. This relation is discussed in greater detail in the chapter III.

Estimating Earthquake Damages

Estimates of the total amount of damage expected from an earthquake are the starting point for estimating the costs to different parts of society from an earthquake. Because assessments of the liabilities of insurance companies are based in part on these estimates, it is useful to understand the methods and uncertainties involved.

Many methods have been developed to estimate these damages, but the methods are basically similar.⁶ In general, knowledge of the geology and earthquake history of an area is used to estimate the largest expected earthquake on each fault. Then knowledge of the local geology is used to estimate the extent and intensity of ground shaking from this earthquake.

These estimates of ground shaking are combined with knowledge, obtained from many previous earthquakes, about the vulnerability of each type of structure to ground shaking in order to estimate the likely maximum percentage of damage to each type of structure in the area from the earthquake. These estimates are combined with an inventory of the structures in the area to estimate the maximum likely total losses in the area from the earthquake. There are uncertainties in each element of this data—the distribution of ground shaking from a given earthquake, the damage to buildings from a given amount of shaking, and the inventory of buildings in each area. Because of these uncertainties, the total losses are only approximate to a factor of two or three.⁷

While this general method is common to many damage estimation methods, many people have developed different methods for different uses. There is no standard method and as a result it is often difficult to make meaningful comparisons between estimates of damages for different earthquakes or estimates of the damages from the same earthquake made at different times.

A difficulty in making loss estimates is in valuing the amount of damage.⁸ There are sometimes substantial differences between the replacement costs and appraised value of a property. In addition, for minor damage, the cost of the damage will depend on how it is repaired. For example, an earthquake could cause cracking in paint and plasterboard that poses no threat to the structural integrity of a house. The homeowner could either ignore this damage, repair it him or herself at a low cost, or pay substantially more to have it repaired professionally. The cost of having it repaired could be especially high after an earthquake, when there would be a high demand for repair work. Some studies use the cost of replacement or professional repair as the means of valuing damage but many studies are not explicit about which damage valuation method they use.

The method to estimate losses described above is only for damage to buildings and other structures due to ground shaking. Losses to other property, such as automobiles, and losses due to causes other than ground shaking can be estimated in a similar manner, but often with greater uncertainty. For example, the amount of automobile damage will depend greatly on the time of day, and losses due to fire will depend in large part on the weather conditions and on actions taken by firefighters and others after the earthquake.

Maximum Losses Expected from Earthquakes

The potential for very large losses is what distinguishes earthquakes from other natural hazards and is why both society in general and insurance companies in particular are concerned about earthquakes. Certain credible earthquake scenarios would result in over \$60 billion of total property losses. These losses are roughly an order of magnitude greater than losses from any hurricane to date.

Studies have estimated the losses from the largest earthquakes expected in several regions of the country. The most heavily studied area has been California. A 1981 study of expected damages from four California earthquake scenarios produced the following estimates of the maximum likely *property loss*:⁹

These earthquakes are also expected to cause between 3,000 and 23,000 deaths.¹⁰

TABLE 3.—PROPERTY DAMAGE FROM POSSIBLE CALIFORNIA EARTHQUAKES

(In millions of 1980 dollars)

Location	Buildings	Contents	Total
San Francisco Area:			
San Andreas fault: M=8.3	25,300	13,400	38,700
Hayward fault: M=7.5	28,700	15,200	43,900
Los Angeles Area:			
Newport-Inglewood fault: M=7.5	40,700	21,500	62,200
San Andreas fault: M=8.3	16,300	8,600	24,900

A few words about these figures are in order. The figures represent the maximum damages that are reasonable to plan for. They are neither the most likely amount of damage (which would be somewhat lower) nor the largest damages that could be imagined in certain scenarios. For example, in unusually windy and dry conditions, fires after an earthquake could cause a greater amount of damage. This study notes that these figures do not include losses to transportation or communications systems, dams, or military installations, and do not include losses due to unemployment or lost business revenues. A similar estimate of earthquake losses has been made for the central United States. A recent draft report on the expected damages to six cities in the central United States from earthquakes in the New Madrid fault zone led to the following damage estimates (intended for emergency planning purposes only):¹¹ for a Richter Magnitude 7.6 event, the total damages to structures and utilities was estimated to be \$38.2 billion. For an earthquake with the same 8.6 magnitude as the 1811 and 1812 New

Madrid earthquakes, the total damages were estimated to be \$52 billion. Most of this damage would occur in Memphis, TN. These potential earthquakes in California and the central United States are the most damaging earthquakes expected in the United States. Earthquakes in many other parts of the United States could also be quite damaging, but the damage estimates do not surpass those for the areas described above.

Expected Annual Losses From Earthquakes

These catastrophic earthquakes occur rarely and the average annual loss from earthquakes is much less than the loss in one catastrophic earthquake. Estimates of the annual expected earthquake losses for the contiguous United States in 1980 dollars range from \$0.6 billion per year¹² to \$2.0 billion per year.¹³ The U.S. Geological Survey expects to make a more definitive assessment in the near future.¹⁴

These estimated annual earthquake losses are much higher than the historical losses. Table 4 lists major earthquakes that have struck the United States. From this table it can be seen that catastrophic earthquakes are relatively rare and that the United States has been relatively lucky—major earthquakes have not recently struck heavily populated areas. This fortuitous history cannot be expected to continue. Three earthquakes that occurred in the United States in the past 200 years (the New Madrid, MO earthquakes of 1811–12, the 1857 southern San Andreas earthquake, and the 1906 San Francisco earthquake) could produce damages close to those described as maximum probable earthquakes if they reoccurred today. If this is typical, one could expect a catastrophic earthquake to occur about every 65 years. In the last 200 years there have also been other damaging earthquakes, such as the one in Long Beach, CA in 1933, that would cause much greater damage if they reoccurred today.

TABLE 4.—SIGNIFICANT DAMAGING EARTHQUAKES, 1755 TO 1983, IN THE UNITED STATES, PUERTO RICO, AND THE VIRGIN ISLANDS

[Damage in millions of dollars (1979 dollars)]

Date	Location	Damage	Dead	Magnitude					$M_b \times 10^{2.5}$ dyn cm
				M_1	M_2	m_0	M_s	M_o	
Nov. 18, 1755.....	Cape Ann, Massachusetts.....								
Dec. 16, 1811.....	New Madrid, Missouri.....					7.2	8.6	8.5	210
Jan. 23, 1812.....	do.....					7.1	8.4	7.5	210
Feb. 7, 1812.....	do.....					7.3	8.7	7.5	210
Dec. 8, 1812.....	San Juan Capistrano, California.....		40	6.9					
Dec. 21, 1812.....	Santa Barbara, California.....			7.1					
June 10, 1836.....	Hayward, California.....			6.8					
June 1838.....	San Francisco, California.....			7.0					
Apr. 16, 1844.....	Off Puerto Rico.....			7½					
Jan. 9, 1857.....	Fort Tejon, California.....						8.3	7.8-7.9	530-900
Nov. 18, 1867.....	Virgin Islands.....			7¼-8					
Apr. 2, 1868.....	Hawaii, Hawaii.....			7½-7¾					
Oct. 21, 1868.....	Hayward, California.....			6.8					
Feb. 19, 1871.....	Off Molokai, Hawaii.....			7					
Mar. 26, 1872.....	Owens Valley, California.....		27					7.8	500
Aug. 10, 1884.....	New York, City, New York.....		0						
Aug. 31, 1886.....	Charleston, South Carolina.....		60			6.8		6.8	20
Oct. 31, 1895.....	Charleston, Missouri.....					6.2			
May 31, 1897.....	Giles County, Virginia.....		0						
Sept. 3, 1899.....	Cape Yakataga, Alaska.....			8.3					
Sept. 10, 1899.....	Yakutat Bay, Alaska.....			8.6					
Dec. 25, 1899.....	Hemet, California.....		6	6.6					
Apr. 18, 1906.....	San Francisco, California.....	2,000	700	6.8-7			8¼	7.7	350-430
June 22, 1915.....	El Centro, California.....	10.6	6						
Oct. 2, 1915.....	Pleasant Valley, Nevada.....		0	7¼					
July 26, 1917.....	Mona Passage, Puerto Rico.....			7.0					
Apr. 21, 1918.....	Riverside County, California.....	1.4	0				6.8		
Oct. 11, 1918.....	Mona Passage, Puerto Rico.....	28.6	116				7.5		
Sept. 29, 1921.....	Elsinore, Utah.....		0						
Oct. 1, 1921.....	do.....		0						
June 27, 1925.....	Manhattan, Montana.....	1.8	0			6¾			
June 29, 1925.....	Santa Barbara, California.....	47	13		6.2				
Jan. 1, 1927.....	Imperial Valley, California.....	5.4	0		5.8				
Aug. 16, 1931.....	Mount Livermore, Texas.....		0	6.4					
Dec. 20, 1932.....	Cedar Mountain District, Nevada.....		0	7.3					
Mar. 11, 1933.....	Long Beach, California.....	266	115			6.3	6¼	6.2	2
Mar. 12, 1934.....	Kosmo, Utah.....		0	6.6					
Oct. 19, 1935.....	Helena, Montana.....	19	2				6.2		
Oct. 31, 1935.....	do.....	6	2				6.0		
Mar. 2, 1937.....	Anna, Ohio.....		0						
May 19, 1940.....	Imperial Valley, California.....	33	9		6.4		6.7	7.0	30
Nov. 14, 1941.....	Torrance, California.....	5	0				5.4		
July 28, 1943.....	Off Puerto Rico.....			7¼					
Sept. 5, 1944.....	Massena, New York.....	8	0				5.6		
Apr. 1, 1946.....	Unimak Island (Aleutians), Alaska.....	90	173				7.4		
Apr. 10, 1947.....	Barstow, California.....		0				6.4		
Apr. 13, 1949.....	Olympia, Washington.....	80	8				7.0		
Nov. 18, 1949.....	Long Beach Harbor, California.....	30	0		3.7				
Aug. 15, 1951.....	do.....	9	0						

TABLE 4.—SIGNIFICANT DAMAGING EARTHQUAKES, 1755 TO 1983, IN THE UNITED STATES, PUERTO RICO, AND THE VIRGIN ISLANDS—Continued

[Damage in millions of dollars (1979 dollars)]

Date	Location	Damage	Dead	Magnitude					$M_b \times 10^{25}$ dyn cm
				M^1	M_L^2	m_b^3	M_s^4	M^5	
Aug. 21, 1951	Kona, Hawaii		0				6.9		
July 25, 1952	Kern County, California	150	12		7.2		7.7	7.5	200
Aug. 22, 1952	Bakersfield, California	30	2				5.8		
Feb. 21, 1954	Wilkes-Barre, Pennsylvania	3	0						
July 6, 1954	Fallon, Nevada		0				6.8		
Dec. 16, 1954	Dixie Valley, Nevada		0	7.1					
Dec. 21, 1954	Eureka, California	6	1				6.6		
Jan. 25, 1955	Long Beach Harbor, California	8	0						
Oct. 23, 1955	Concord, California	3	1				5.4		
Mar. 9, 1957	Andreanof Islands (Aleutians), Alaska	8	0				8.3	9.1	
Mar. 22, 1957	Daly City, California	3	0				5.3		
July 9, 1958	Lituya Bay, Alaska		5				7.9	8.2	
Aug. 18, 1959	Hebgen Lake, Montana	26	28				7.1		
Apr. 4, 1961	Long Beach Harbor, California	11	0						
Aug. 30, 1962	Cache County, Utah	5	0				5.8		
Mar. 27, 1964	Prince William Sound, Alaska	1,020	131				8.4	9.2	82,000
Apr. 29, 1965	Seattle, Washington	28	7				6.5		
Oct. 1, 1969	Santa Rosa, California	13	0				5.6		
Feb. 9, 1971	San Fernando, California	900	58		6.4		6.6	6.6	10
July 30, 1972	Southeastern Alaska		0	7.6					
Feb. 21, 1973	Point Mugu, California	2	0				5.2		
Apr. 26, 1973	Hilo, Hawaii	9	0				6.2		
Feb. 2, 1975	Near Islands, Alaska		0	7.6					
Mar. 28, 1975	Pocatello Valley, Idaho	1	0				6.1		
Nov. 29, 1975	Kalapana, Hawaii	5	2				7.2		
Aug. 13, 1978	Santa Barbara, California	15	0				5.6		
Feb. 28, 1979	St. Elias, Alaska		0	7.1					
Oct. 15, 1979	Imperial Valley, California	21.1	0		6.6			6.5	6
May 2, 1983	Coalinga, California	31	0		6.7	6.2	6.5	6.4	5

¹ Unreferenced magnitude.² Local (Richter) magnitude.³ Body-wave magnitude.⁴ Surface-wave magnitude.⁵ Moment magnitude.

Source: Schnell, Mary L. and Darrell G. Herd, eds. National Earthquake Hazards Reduction Program: Overview. Report to the United States Congress. Alexandria, VA, U.S. Geological Survey Circular 918. 1983. p. 4.

Predictability of Earthquake Damage

Another factor that affects the insurability of earthquakes is the predictability of earthquake damage. This includes both the geological aspects of predicting when and where earthquakes will occur, and the engineering aspects of predicting which buildings will be damaged if an earthquake occurs. The two aspects have different effects on earthquake insurance.

Predicting the time and place of earthquakes may make earthquake insurance more difficult, with more precise predictions causing greater difficulties. Short-term predictions—predictions a few days, weeks, or months in advance—could be very disruptive to earthquake insurance. One can expect that more people would want to buy earthquake insurance but that insurance companies would be unwilling to sell or renew insurance policies. Insurance companies currently typically

suspend selling of earthquake insurance for 30 to 60 days following a major earthquake to protect themselves against aftershocks. There might need to be special regulations governing the buying and selling of earthquake insurance following an earthquake prediction. There is currently no reliable short-term prediction system in place, and short-term earthquake prediction has turned out to be more difficult than once thought, but it is possible that there will be advance warning of the next great San Andreas earthquake. In areas of the country where faults are not on the surface, such as the eastern United States, short-term predictions may be less likely.

Long-term predictions—predictions on the order of years or decades—are already being made. Studies by the U.S. Geological Survey (USGS) indicate that a moderate earthquake is likely to occur at Parkfield, CA within 2 to 5 years of years of 1988.¹⁵ This is the first prediction to be endorsed by the National Earthquake Prediction Evaluation Council. As described previously, the USGS has also assessed the probabilities and magnitudes of earthquakes occurring along other parts of the San Andreas fault in the next 30 years (see figure 4, p. 11). Long-term predictions will have effects similar to, but less drastic than, short-term predictions. They can be expected to increase the demand and to reduce the availability of insurance in areas where earthquakes are expected.

Identifying which buildings are likely to be damaged in the event of an earthquake also will influence the demand for insurance for specific buildings and the willingness of insurers to insure the buildings. As better information becomes available on which buildings will be damaged (based on building construction, soil conditions, and proximity to faults), insurance companies will be increasingly able to set rates according to the likely damage to the buildings. This is likely to make insurance for seismically vulnerable buildings cost more and insurance for seismic-resistant buildings cost less. This will provide an incentive to use better buildings and to replace old vulnerable buildings.

Identifying vulnerable buildings alone is not likely to make the buildings uninsurable because the probability of the earthquake occurring in any year is likely to be sufficiently low as to allow a reasonable rate to be charged. But the combination of predicting an earthquake and identifying vulnerable buildings is likely to make the vulnerable buildings virtually uninsurable, as the "risk" of loss would become a near certainty.

OTHER NATURAL HAZARDS

Several other natural hazards, including floods, volcanoes, landslides, and windstorms, are sometimes included with earthquakes as natural hazards that the private sector can not adequately insure. Table 5 compares the annual and sudden loss potential of different natural hazards.

Floods

Flooding occurs along both rivers (riverine flooding) and coasts. Riverine flooding is usually caused by rainfall, snow melt, or dam failure. Coastal flooding is usually caused by the combination of high

tides, surges from storms, and wind-driven waves. Much coastal flooding is associated with hurricanes. Tsunamis also cause coastal flooding. Both riverine and coastal flooding occur in fairly well-defined areas—in flood plains and along coasts. Floods are more consistent from year to year but are less catastrophic than earthquakes.

Floods are currently insured under the National Flood Insurance Program administered by the Federal Insurance Administration. This is discussed to a greater extent in the appendix. Some disaster insurance proposals would consolidate the flood insurance program with an earthquake insurance program.

TABLE 5.—ANNUAL LOSSES FROM GEOLOGIC AND HYDROLOGIC HAZARDS ¹⁶

[Billions of dollars]

Hazard	Annual loss	Sudden loss potential
Earthquakes—ground shaking, surface faulting, earthquake-induced ground failure, tsunamis.....	0.6	50
Floods—flash floods, riverine floods, tidal floods.....	3	5
Ground failures—landslides, expansive soils, subsidence.....	4	6
Volcanic eruptions—tephra, lateral blasts, pyroclastic flows, mud flows, lava flows.....	(¹)	3

¹ Inadequate data.

Non-Seismic Ground Failures

Non-seismic ground failures include landslides, expansive soils, and subsidence. Landslides—movement of soil and rock down slopes—are a significant hazard in every state and cause an estimated \$1.5 billion in damages each year.¹⁷ Landslides occur in narrowly defined and identifiable areas. *Expansive soils* are soils and soft rocks that swell or shrink due to changes in moisture content. The USGS cites estimates that expansive soils cause over \$2 billion per year in damages to homes, buildings, and other structures.¹⁸ Some estimate the annual costs to be as high as \$7 billion.¹⁹ *Subsidence* is the lowering or collapse of land surfaces. It can be caused by natural means, such as the collapse of underground caverns, or by man-made means such as the withdrawal of fluids from the ground. Subsidence is also geographically localized. Some disaster insurance proposals have included non-seismic earth movements.²⁰

Volcanoes

Volcanoes can cause damage through several means, including ash and rock falls, emissions of hot or poisonous gases, and mudflows. Ash and mud from volcanoes can disrupt drainage patterns and cause flooding. The average annual losses from volcanoes are less than those from earthquakes, floods, or ground failures, but when volcanoes occur they can cause near-total loss of life and property in nearby areas. Mudflows from the 1985 eruption of Nevada del Ruiz in Colombia resulted in over 20,000 deaths, an occurrence that is by no means unique. Similarly, an eruption in 1902 on the island of Martinique in the Caribbean killed some 30,000 people.²¹ Volcanoes in the United States are largely away from population centers, which reduces their threat to lives and property. Eruptions, however, can still cause significant

damage. The total cost of the 1980 Mount St. Helens eruption was estimated at over \$1 billion.²² Mudflows from other volcanoes in the Pacific Northwest would threaten several downstream towns.

Windstorms

Windstorms include hurricanes, tornadoes, and other wind storms. Hurricanes can affect the Atlantic and Gulf coasts of the United States and have the potential to be quite damaging. It is estimated that a major hurricane hitting a major population center could cause \$8-12 billion in insured damages²³ and that the average annual property losses could be around \$3.5 billion.²⁴

Tornadoes can occur over much of the United States but are most common in the central United States. Single tornadoes cause less damage than hurricanes, but their expected annual losses could be higher, in the range of \$5 billion per year.²⁵

CHARACTERISTICS OF NATURAL HAZARDS AFFECTING INSURANCE

For a risk to be attractive to an insurer, it should ideally have several characteristics. There should be sufficient data on past losses to estimate the chance of future loss. It should be possible to define a loss that has occurred. There should not be a potential for catastrophic loss that would threaten the financial stability of the underwriting company. And the insured risk must be accidental.

Earthquakes and other natural hazards lack several of these characteristics. Earthquakes in particular have a potential for catastrophic loss that can jeopardize an insurance company's financial stability. Future losses from many natural disasters cannot be adequately predicted based on the past record because the disasters occur infrequently at any location, and too many variables, such as construction practices, change between disasters. Instead losses must be estimated from technical studies, in which insurance companies traditionally have less confidence. In addition, there may be a strong tendency for more poor risks than good risks to buy insurance for natural hazards; this is likely when the hazard is narrowly defined geographically. Only those people living in a flood plain, for example, will choose to buy flood insurance. This phenomenon, termed "adverse selection," results in a poor spread of risk and an inadequate premium base, and makes it difficult to offer insurance at affordable rates.

While the potential for catastrophic loss is the major problem for earthquakes, adverse selection is the major difficulty with insuring floods, volcanoes, landslides, and other soil movements, all of which occur in relatively narrow geographic areas. Only those at high risk will be interested in purchasing insurance, making it difficult to keep rates affordable. Earthquakes are also prone to adverse selection, but to a lesser degree because ground shaking occurs over broad areas. As discussed above, increased knowledge about the location and timing of earthquakes and the susceptibility of structures to damage may make it possible to better identify which structures are likely to be damaged. This is likely to make it more difficult to spread the risk.

BACKGROUND ON INSURANCE²⁶

This section provides some background on insurance operations and the insurance industry that may be useful in understanding earthquake insurance problems and proposed solutions. It describes the structure of the insurance industry, the market cycles that characterize property-casualty insurance industry operations, the current regulation of the insurance industry, and the types of earthquake insurance.

RISK AND INSURANCE

"Risk" refers to the chance of loss or damage to something of value.²⁷ The fundamental principle of insurance is the spreading of risks, i.e., containing the losses of some few by spreading the cost of losses among many. Insurance is probably the most practical and widely used method for contending with the magnitude and variety of risks that confront individuals, businesses, and society as a whole.

INSURANCE INDUSTRY STRUCTURE

The insurance business has traditionally been divided into two major segments. One side, usually referred to as "life and health" is comprised of companies writing life, health, disability, and annuity insurance.²⁸ The other side, known as "property and liability" or "property and casualty," writes such lines as automobiles, homeowners, workers compensation, marine insurance, fidelity and surety insurance, and a great diversity of commercial property and liability (casualty) coverages. The two segments of the business remain largely separate in corporate structure, in regulatory treatment, and in many phases of operation, although the separation has narrowed considerably during the last quarter of a century. "Earthquake insurance"—coverage specifically for damage from earthquakes—is a property and casualty coverage, but earthquakes can cause losses to life, health, and disability insurance by causing injury and deaths.

The insurance industry is divided in several other ways that are relevant to earthquake insurance. One broad division is between "personal lines" coverages for individuals or families and "commercial lines" coverages for businesses. Personal lines include life and health coverages and such property lines as automobiles and homeowners insurance. Commercial lines encompass a large range of property and liability types of coverages that are purchased by businesses.

Earthquake insurance is written for both personal lines and commercial lines; the problems and issues are somewhat different for each category. For personal lines, the main problem has been a failure or inability of homeowners and small businesses to purchase earthquake insurance. This leaves them, and, through disaster assistance and tax liabilities, the Federal Government, exposed to losses. For commercial lines, the major problems have been the availability and affordability of insurance (as commercial lines are more subject to market cycles) and the industry's vulnerability to catastrophic losses.

State regulatory authorities have traditionally been more concerned with protecting individual insurance purchasers than with protecting corporate insurance buyers. Corporations have sophisticated insurance purchasers (risk managers) who can deal in the marketplace on an equal footing with the sellers of insurance products. By comparison, the individual insurance purchaser lacks the market knowledge and economic leverage of the corporate risk manager and thus has traditionally warranted more regulatory protection.

REINSURANCE

Another division of the insurance industry, and an important division for earthquake insurance, is between primary insurers and reinsurers. Reinsurance is essentially insurance that insurance companies buy to protect themselves against large losses. They transfer some of the risk (and some of the premiums) to other insurance companies to spread the risk of a large loss among many companies. Reinsurance can work in several ways. A primary insurer can accept the first layer of a risk (e.g. the first million dollars of loss) and pass the remaining portion of the risk to a reinsurer (e.g., all the remaining potential loss) who in turn typically accepts a layer of risk and passes the remainder of the risk to another reinsurer. The primary insurer can also reinsure a certain percentage of the risk. Some reinsurance is sold by companies that are strictly reinsurance companies and some is sold by primary insurance companies that have reinsurance departments.

Reinsurance operates as an international market; domestic companies often obtain reinsurance from companies outside of the United States. The advantage gained is that the risks are spread broadly on a worldwide basis. The disadvantage is that the offshore reinsurers are beyond the control of U.S. state regulatory officials and may not be as reliable in honoring claims.

Because earthquake risks are catastrophic in nature, earthquake risks are heavily reinsured, and the reinsurance industry is likely to bear a significant share of the losses from a catastrophic earthquake. Thus the ability of the reinsurance industry to handle earthquake insurance is of major concern. This will be discussed more in chapter III.

PROPERTY-CASUALTY INDUSTRY MARKET CYCLES AND RECENT INDUSTRY PERFORMANCE

The property-casualty sector of the insurance business in the United States has, for much of its modern history, alternated between "soft" and "hard" (or "tight") insurance markets. These market fluctuations, of varying degrees of intensity and duration, are referred to in insurance circles as the "underwriting cycle." When rates are adequate, risk selection careful, and the industry is generally performing well (profitably), new capital is attracted and begins to enter the marketplace. This new capital can come from several sources. Insurers can commit more of their assets to underwriting profitable lines of business. New insurers, such as offshore captive insurers, foreign insurers, and domestic insurers who generally write other lines of business can also enter the market. These new sources of insurance capacity begin to generate increased

competition for the available premiums in any particular market, and price-cutting (discounting) begins. Discounting can be particularly intense for commercial lines of insurance because corporate insurance buyers are sophisticated and can use their market knowledge and economic leverage effectively. Increased competition also means that underwriting standards for risk selection begins to erode and insurers, in their desire to maintain market shares, begin to take on less-than-standard business, also at discounted rates. Looser underwriting practices and inadequate rates, over time, inevitably result in rising claims losses and possible loss of profitability.

When competition is too severe and losses too high, the market begins to harden. An inability of primary carriers to obtain reinsurance may hasten this process. Capacity shrinks, and some insurers withdraw from the market. The remaining insurers raise prices and tighten underwriting standards. When an insurance market hardens and capacity shrinks, prices rise and underwriting becomes more selective. Problems, sometimes severe ones, of availability and affordability of necessary insurance coverages result. After rates rise and underwriting becomes more selective, the industry eventually becomes profitable again. With the return of profitability, new capital is attracted. Then the ensuing competition among insurers for a share of the available premium volume eventually leads to another soft market.

The traditional measure of economic health and performance of an insurance operation is the "combined ratio." This ratio relates claim losses to premiums earned and underwriting expenditures to premiums written. A combined ratio of 100 means the underwriting operation breaks even, below 100 means an underwriting profit, and above 100 indicates a loss.

Property-casualty insurance companies generally pay out more for claims and expense than they receive in premiums; this is known as an underwriting loss. The property-casualty segment of the insurance industry has lost money on underwriting every year from 1979 through 1985. For example, the combined ratio (after dividends to policy holders) was 118 in 1984 and 116.5 in 1985.²⁹

Despite underwriting losses, however, many companies have been able to show an overall profit for most years because profits that come from investing premium dollars more than offset underwriting losses. The high interest rates of recent years helped insurers to reap high investment incomes. To a large extent, many companies relied on this income, rather than on positive underwriting results, for favorable year-end performance. This strategy has been dubbed "cash-flow underwriting," and the concept has been criticized by some financial experts and State regulators alike. During the last "soft cycle," the property-casualty insurance market was characterized by many insurance companies practicing cash-flow underwriting, discounting premiums in an attempt to gain market share and to generate premium dollars to be invested at the then-prevailing high interest rates. In 1985, the combination of falling interest rates, unfavorable claims experience resulting from inadequate rates and poor selection of risks, and other market forces com-

pelled insurers to increase premium rates and to be more selective in their underwriting.

CONNECTION BETWEEN MARKET CYCLES AND EARTHQUAKE INSURANCE PROBLEMS

Earthquake insurance is susceptible, perhaps unusually so, to the underwriting market cycle. During the "soft" part of the underwriting cycle, insurance companies can compete for business by discounting earthquake insurance with little risk because major earthquakes rarely occur. Even with inadequate rates, insurers can still make a profit on this class of business for many years until a severe earthquake strikes. Conversely, in the "hard" part of the underwriting cycle, when insurers are concerned about being overextended, insurers may be especially reluctant to underwrite earthquake risks because if an earthquake occurred, it would greatly exacerbate financial problems.

During the "soft" part of the most recent underwriting cycles, commercial earthquake coverage was practically given away to attract new customers. As the market hardened, earthquake rates on commercial properties increased sharply even though earthquake losses have been negligible and earthquake insurance has been consistently profitable.³⁰

The question sometimes arises as to whether earthquake insurance problems are mainly symptoms of the larger insurance "crisis." Earthquake insurance problems are related to, but distinct from, the market cycles in the insurance industry. A "hard" insurance market exacerbates, but does not cause, earthquake insurance problems. While the underwriting cycle affects the industry's ability to cope with a catastrophic earthquake and affects the availability and rates for earthquake insurance, a catastrophic earthquake could threaten the solvency of insurance companies even during a period of industry profitability. In addition, as is described in more detail in the next chapter, the failure of homeowners and small businesses to purchase earthquake insurance is not a result of the insurance industry's market cycles. Earthquake insurance is a problematic line of insurance even when the insurance industry is healthy, and insurance trade groups have been concerned about the problem through all stages of the market cycle.

INSURANCE REGULATION

The United States is atypical among nations in not supervising its insurance industry at the national level. The insurance industry is the only large-scale financial service sector not directly regulated at the Federal level of government. Insurance regulation has been by statute and long precedent a State, rather than a Federal, concern. Legislation to provide for Federal supervision of the insurance industry was first proposed in the 1860s. In *Paul v. Virginia* (1869), the U.S. Supreme Court ruled that insurance was not interstate commerce and therefore not subject to Federal regulation. In 1944, the Court reversed its earlier decision by ruling in *U.S. v. South-Eastern Underwriters Association* that insurers were subject to Federal antitrust laws. The Congress responded in 1945 by enacting the McCarran-Ferguson Act (15 U.S.C. 1011-15 (1970)). The Act exempted the "business of insurance" from

Federal antitrust laws to the extent that States provide similar antitrust supervision. In effect, the Act reaffirmed the traditional principle of State supervision and regulation of insurance and exempted the insurance industry from those sections of the antitrust laws that prohibited price-fixing. In the years since its enactment, the McCarran-Ferguson Act has been the target of persistent criticism by those who favor Federal regulation of the insurance industry, but has in general received support from the States and the insurance industry.

The U.S. system of insurance regulation evolved from early State regulatory activities, and, either as cause or effect, insurance development and thinking has been primarily geared to a State-by-State approach. States supervise finances, rates, claims, and marketing, with control exerted through periodic, usually triennial, audits. The quality of State insurance regulation, however, has been characterized by critics as uneven, and the coordination of interstate regulatory activities can present serious problems. The multiplicity of State insurance regulations lacks uniformity, and critics of State regulation emphasize the duplication, complexity, and inefficiency that may result from non-uniformity. State insurance regulation has developed into a complex institution with strong vested interests. Insurers have, by and large, learned to live with the existing system and have shown distaste for change in regulatory patterns.

Proposals for a Federal involvement in earthquake insurance have sometimes been viewed as a step towards increased Federalization of insurance regulation, and have sometimes brought hostile reactions from insurers, particularly those that operate primarily within a single State, and from State insurance regulatory officials.

An important way in which the Federal Government affects insurers is through accounting and tax provisions. These regulations discourage insurers from building reserves for catastrophes by taxing such reserves as profits.³¹

When a loss is reported to an insurance company, the company establishes a reserve for the amount for which the claim is being adjusted to ensure that funds will be available to pay the claim. These reserves are not taxed by the IRS. In addition, insurers can establish an untaxed reserve for claims that they believe have occurred but which have not been reported at the end of a given accounting period. This is called the Incurred But Not Reported Loss Reserve (IBNR).

Beginning in about 1969, insurance companies began to set aside additional reserves to anticipate future catastrophes. In March 1975, however, the Financial Accounting Standards Board (FASB), an independent Federal agency, released "Statement of Financial Accounting Standards No. 5: Accounting for Contingencies."³² This statement prohibited companies from accruing catastrophic reserves unless it was probable that the loss had already occurred. Thus companies could no longer accumulate catastrophe reserves before a catastrophe took place. Under the current Federal tax provisions, premiums collected by private companies that are put in a reserve fund for catastrophes are treated like excess profits, and hence taxed at a high rate.³³ The only

current provision available to companies insuring catastrophic risks is "loss carryback" and "loss carryforward." Current tax law permits a loss carryback of three years and a loss carryforward of seven years. These provisions could be inadequate in view of the long return period and large potential losses of catastrophic earthquakes.

TYPES OF EARTHQUAKE INSURANCE

Earthquake insurance, like other types of property insurance, is either written on a "named-peril" basis or an "all-risk" or "excluded peril" basis. Under a "named-peril" basis, only risks that are named are covered, while under an all-risk or excluded peril basis, all risks except those that are specifically excluded are covered. While a policy with a long list of named perils could be more comprehensive than an all-risk policy with a long list of exclusions, generally the all-risk coverage provides for more comprehensive coverages than a named peril coverage.

Earthquake insurance was offered as an endorsement to fire policies as early as 1916.³⁴ In the 1920s and 30s, marine insurance companies began expanding their coverages to "inland" (i.e. non-marine) risks, by providing all-risk policies to businesses such as jewelers and furriers. This business became known as "inland marine" insurance. Earthquake coverage was generally not excluded from these coverages. The present "Differences in Conditions" (DIC) policies, a comprehensive property coverage, developed out of these inland marine policies. The inland marine companies were restricted by agreement with the National Association of Insurance Commissioners (NAIC) to not write policies where the element of transportation was lacking. Thus the inland companies did not insure individual residences. The competitive influence of the marine insurance companies led to a degree of flexibility in the property insurance companies which developed a special multiple-peril (SMP) form—an all-risk coverage. Earthquakes are a standard exclusion to this form, although it can be added by endorsement.

EARTHQUAKE INSURANCE RATES

The Insurance Services Office (ISO)—an industry technical services and statistical organization that develops model rates—first developed earthquake insurance rates after the 1925 Santa Barbara earthquake. These rates have changed relatively little since then.³⁵ Insurance companies sometimes use these model rates or modify them based on their own experience or needs. Rates for earthquake insurance can be expected to bear some relation to the average annual loss expected for the type of property in an area, and vary considerably with the type of building and the location.

The average annual losses for wood frame residences in California and in the metropolitan San Francisco area, one of the highest risk and most studied areas, have been calculated to be: ³⁶

	Average Annual Loss, \$ per 1,000 Replacement Value			
	No deduct- ible	\$250 deduct- ible	2% deduct- ible	5% deduct- ible
Metropolitan San Francisco	1.00	0.80	0.70	0.50
All California	0.60	0.50	0.50	0.30

Actual rates being charged in California are several times higher than these average annual losses, from \$1.50 to \$2.00 per thousand insured (\$150 to \$200 for a \$100,000 house).³⁷ These rates are with either a 10 percent or a 5 percent deductible. The difference between the actual rates and the expected annual losses is due to several factors—the rates have to cover taxes, profits, and the cost of doing business, and may also reflect concern over the inability to build tax-free reserves and over likely adverse selection.

The average annual earthquake losses for other types of buildings in the San Francisco Bay Area range from \$1.40 per \$1000 insured for metal buildings to \$15.80 per \$1000 insured for unreinforced masonry buildings.³⁸ ISO rates for the San Francisco Bay Area range from \$1.43 per \$1000 insured with a 5 percent deductible to \$10.00 per \$1000 insured with a 10 percent deductible for these classes of buildings.³⁹ These rates and expected losses for California are the highest in the Nation.

UNDERWRITING EARTHQUAKE RISKS

These rates described above are general rates for broad types of properties. Underwriters modify these rates for specific properties. Underwriters may consider the design and condition of the building, the local soil conditions, and market conditions in determining how to underwrite a property. Insurance companies vary in their technical expertise and in how much detail they examine the property for seismic risk.

Chapter III

EARTHQUAKE INSURANCE PROBLEMS

This chapter discusses the two main earthquake insurance problems: the lack of earthquake insurance purchased by homeowners and small business, and the possible financial vulnerability of insurance companies to a catastrophic earthquake.

LACK OF EARTHQUAKE INSURANCE COVERAGE

DESCRIPTION OF THE PROBLEM

Without insurance, either the people struck by disaster, or some other group, typically the Federal Government, will bear the cost of recovering from a disaster. Most people agree that this is undesirable; that it is socially desirable for outside resources to be available to a community that is struck by a disaster, and that, for reasons described later, insurance is preferable to governmental disaster assistance. For this reason, many people consider a lack of earthquake coverage to be undesirable.

Earthquake coverage problems are considerably different for residential and commercial markets. For residences, earthquake insurance is generally available, but for a variety of reasons most people do not buy it. This failure to purchase is often viewed as a public policy problem because extensive uninsured losses put a potential burden on the disaster assistance system.

For large businesses a decision not to carry insurance is typically not viewed as a social problem although an unavailability or unaffordability of earthquake insurance coverage may be. Large corporations are usually considered to be competent in making insurance decisions. They have access to financial and technical resources including engineering consultants who can recommend whether to insure or not. Large companies with geographically dispersed operations also have a built-in spread of risk—only a small part of their assets could be damaged by a single earthquake.

If earthquake insurance is unavailable or exorbitantly expensive, however, some people may seek governmental action to correct the situation. This can happen when the property-casualty insurance business is in the "hard" part of the underwriting cycle. When this happens, as has occurred in 1985 and 1986, many companies may drop their earthquake coverage.

The situation for small businesses can be viewed as intermediate between that of homeowners and large businesses. Small business, may lack the financial and technical resources and the natural spread of risk of large businesses, but may still be subject to the same problems of availability and affordability.

To explore these problems further, this section discusses the extent of earthquake insurance coverage, the reasons why people choose not to buy earthquake insurance, and the relative attributes of insurance compared to disaster assistance. The next chapter discusses options to increase earthquake insurance coverage.

EXTENT OF EARTHQUAKE INSURANCE COVERAGE

Residential Coverage

It is well documented that few homeowners are insured for earthquakes.⁴⁰ Few homeowners voluntarily buy insurance for natural disasters. Prior to 1985, only about 7 to 8 percent of residential insurance policies in California covered earthquakes.⁴¹ On January 1, 1985, a California law (Assembly Bill No. 2865) went into effect requiring insurance companies to offer earthquake insurance to all residential policy holders. Early indications suggest that this will increase the purchase of earthquake insurance to 10 to 15 percent of policy holders.⁴² Some of these homeowners may not renew the insurance. In lower risk States, fewer homes were insured for earthquakes.⁴³

Commercial Coverage

There is relatively little information available on the extent of commercial coverages. As part of the 1980-81 Federal Insurance Administration-sponsored study, the Wiggins Company surveyed 500 members of the Risk and Insurance Management Society (RIMS), whose members are typically risk managers of *Fortune* 1000 companies.⁴⁴ Of the 500 survey instruments sent out, 162 were returned, and 91 of these 162 had insurance coverages. While the returned surveys were not a representative sample of all large businesses, they indicated that a significant number of large businesses in all parts of the country had earthquake insurance at that time. The level of coverage may have decreased in recent years. It is generally believed that large businesses are much more likely than homeowners to be insured for earthquakes.

There is less information on the extent to which small businesses are insured for earthquakes. It is sometimes assumed, based on little hard data, that small businesses tend to be in between homeowners and large businesses in their propensity to purchase earthquake insurance.

WHY PEOPLE DO NOT BUY EARTHQUAKE INSURANCE

There are many possible reasons why homeowners could choose not to buy earthquake insurance. For many people, the rates and deductibles are high compared to the likely damage to their homes. Others may anticipate that the Federal Government will provide assistance after a major earthquake. Other homeowners have little equity in their homes and thus are at little risk. The lenders, who bear most of the risk, do not require earthquake insurance. A National Science Foundation (NSF)-sponsored study of disaster insurance purchasing decisions, however, found that most people do not reject insurance for these reasons.⁴⁵ Instead, most people do not purchase disaster insurance because they refuse to worry about low-probability losses. The study noted that consumers tend to view insurance for low-probability risks as

a poor investment rather than as a protective mechanism. An implication of the study is that voluntary insurance programs were unlikely to make most people buy insurance. The study points out that most people did not purchase other types of insurance, such as fire and automobile insurance, until it was required.

Earthquake engineers, who are capable of making informed judgments about the costs and benefits of earthquake insurance, differ in their purchasing decisions. Some choose not to purchase it because they believe it is overpriced. Others do buy earthquake insurance because the small risk of total loss of their home is unacceptable and thus the insurance is worth the price.⁴⁶

To some extent peoples' decision not to purchase insurance is related to the other earthquake insurance problem, discussed later in this chapter, of the vulnerability of insurance companies to a catastrophic earthquake. Because insurance companies are concerned about their exposure to earthquake losses, they generally do not aggressively market earthquake insurance and may charge higher rates that reflect this concern. These high rates, in turn, discourage more people from buying the insurance.

DISASTER INSURANCE VERSUS DISASTER ASSISTANCE

To understand why some people believe insurance is preferable to the current system of disaster assistance, it is useful to compare a system of insurance with a system of disaster assistance.

The Current Disaster Assistance System

Under the current system of disaster assistance local governments have the first responsibility to protect life and property and to alleviate suffering after a disaster. The State government assists when the disaster exceeds the capabilities of the local government, and Federal agencies located near the disaster area can assist under their own statutory authorities.⁴⁷ If the disaster requires further resources, the Governor of the state may request that the President declare a "major disaster" or an "emergency". Such a declaration makes additional Federal assistance available.

In a Presidentially declared disaster, there are many forms of help available to homeowners and small businesses. The forms of help that are most similar to the assistance insurance would provide are the following:⁴⁸

- Individual and family grants of up to \$5,000 to meet disaster-related necessary expenses or serious needs when those affected are unable to meet such expenses or needs through other programs or other means;

- Loans to individuals, businesses, and farmers for repair, rehabilitation, or replacement of damaged real and personal property and some production losses not fully covered by insurance;

- Tax relief, including help from the Internal Revenues Service in claiming casualty losses resulting from the disaster and State tax assistance;

—Temporary housing until alternate housing is available for disaster victims whose homes are uninhabitable; minimum essential repairs to owner-occupied residences in lieu of other forms of temporary housing, so that families can return quickly to their damaged homes.

Other aspects of the Federal disaster assistance program include:

—Temporary assistance with mortgage or rental payments for persons faced with loss of their residences because of disaster-created financial hardships;

—Disaster unemployment assistance and job placement assistance for those unemployed as a result of a major disaster;

—Legal services to low-income families and individuals;

—Crisis counseling and referrals to appropriate mental health agencies to relieve disaster-caused mental health problems;

—Distribution of food coupons to eligible disaster victims;

—~~Agricultural~~ assistance, including technical assistance; payments covering a major portion of the cost to eligible farmers who perform emergency conservation actions on farmland damaged by the disaster; and provision of federally owned feed grain for livestock and herd preservation;

—Social Security assistance in the form of expedited claims processing for insured victims who are at least 62 years of age and their families, and for survivors or insured victims;

—Veterans' assistance, such as death benefits, pensions, insurance settlements, and adjustments to home mortgages held by the Veterans Administration (VA), if a VA-insured home has been damaged;

—Waiver of penalty for early withdrawal of funds from certain time deposits;

—Consumer counseling and assistance.

In addition to these forms of aid to individuals and businesses, the Federal Government also provides a variety of assistance to State and local governments following a Presidentially declared disaster.⁴⁹ This assistance comes under a number of Federal programs that the Federal Emergency Management Agency (FEMA) coordinates.

Applicants for aid are required to purchase insurance, if reasonably available, to protect against future losses.

Congress also sometimes passes special legislation to benefit the victims of specific disasters. This aid can take the form of the forgiveness of part, such as the first \$1000, of loans to the Federal Government.⁵⁰ The amount of aid provided often can depend on the politics of the disaster as well as the degree of need.

A catastrophic earthquake would undoubtedly be a Presidentially declared disaster. Smaller earthquakes may not be a Presidentially declared disaster. Without a Presidential declaration, some other types of disaster assistance may still be available. For example, the Administrator of the Small Business Administration (SBA) can declare a "disaster loan area" under the SBA's statutory authority and can provide loans to qualified homeowners and businesses.⁵¹

Problems With Disaster Assistance

There are several reasons why many people believe insurance is preferable to disaster relief or tax policy to provide assistance for disaster victims. A 1980 General Accounting Office report compared loans, grants, and insurance as methods for providing disaster relief and concluded that "insurance is the most efficient and equitable method of providing disaster assistance."⁵² Among the reasons are as follows.

Insurance provides a better incentive to reduce risks. Because the current disaster assistance system subsidizes disaster losses, it is a disincentive to risk reduction. Insurance with rates based on risk, on the other hand, provide an incentive for the policy holder to reduce risks. Because over the long run the cost of a disaster assistance or insurance system will depend largely on the extent to which the system encourages or discourages risky building practices, this is an important difference. Several factors, however, currently limit the effectiveness of insurance in encouraging risk reduction.

First, insurance provides an incentive to reduce risks only to the extent that premiums are based upon the risk. If insurance rates are too low, they can subsidize disaster losses and provide a disincentive for risk reduction. Earthquake insurance rates typically discriminate only between broad classes of buildings, such as different basic types of construction. This would provide an incentive to use more earthquake-resistant classes of buildings, but would not provide a significant incentive to increase the earthquake resistivity of buildings within a class. While some insurers do examine properties to assess their seismic vulnerability, others just assume a certain percent loss based on the class of building without examining the building.⁵³ For these latter insurers, the rates will have less relation to the actual risk, and thus will be a poorer incentive to reduce the risks.

Second, insurance is seen to some extent as a substitute for making engineering changes that would reduce risks. If no insurance or disaster assistance were available, people might reduce risks more than they would if they could insure against the loss.

Third, the people who are responsible for the design of the building and the people who handle insurance matters for a company are usually not in communication at the time when decisions are being made about the design of a building.⁵⁴

As a result of these limitations, insurance currently is only a limited incentive to reducing risks. Companies may try to reduce their insurance premiums by changing the uses for hazardous buildings (to lessen the amount of contents that need to be insured), or may decide to replace hazardous buildings more quickly. When earthquake insurance is less available or less affordable, the incentives are stronger for companies to replace buildings that are high risks. Because few homeowners purchase earthquake insurance, insurance is not currently a major force for reducing residential risks. The experience from the National Flood Insurance Program (NFIP) (described in the Appendix page 53) suggests that insurance rates are not a major incentive for risk reduction, but that the land use planning requirements imposed as a

prerequisite for obtaining flood insurance are a much stronger means of reducing risks. One could expect that imposing land use and building code requirements as a prerequisite for earthquake insurance would be more effective in reducing earthquake hazards than insurance rates.

Insurance provides more complete compensation for damages. Disaster assistance to homeowners is mostly in the form of loans, which increases the level of indebtedness of the homeowners. Insurance, by contrast, provides cash payments.

Insurance is often considered to be more equitable. Insurance provides payment to any insured person who sustains a damage. Certain types of disaster assistance are only available if there is a Presidentially declared disaster; people who suffer identical losses would be treated differently in different types of disasters. Tax deductions for disaster victims benefit those in high tax brackets more than those in low tax brackets. In effect, the Federal Government pays more of the disaster costs of wealthy victims than of poor victims.

An insurance system could be cheaper to the Federal Government. The current system is potentially costly to the Government, due to the cost of disaster assistance grants and loans, and lost tax revenues. Insurance could reduce the need for grants and loans, and could reduce the amount of tax deductions for disaster losses.

Insurance gives people more control over their degree of protection. People have virtually no control over the amount of protection they receive from disaster assistance, and no control over the amount they pay for disaster assistance. With insurance, people can select the amount of protection they receive and the amount they pay.

Insurance may be more efficient in dispensing payments. The disaster assistance is sometimes criticized for delays and paperwork in dispensing payments. With insurance, homeowners would deal with insurance agents rather than the Federal Government.

Thus there is wide agreement that a program of disaster insurance is socially preferable to a system that relies exclusively on disaster assistance. There is disagreement, however, on what such a system should be like. The various options to promote and expanded system of earthquake insurance are discussed in the next chapter.

THE VULNERABILITY OF INSURANCE COMPANIES

The second major earthquake insurance problem is the potential for major earthquakes to render insurance companies financially insolvent. The insurance industry has brought attention to this problem and has developed proposals to address the problem by creating or making available some type of reserve for the industry to draw upon in the event of a catastrophic earthquake. The main issue is one of how serious this risk is to the insurance companies. How large are the possible claims against insurance companies in an earthquake and what is the capability of the industry to meet these claims? If financial vulnerability is a serious problem, what should be done about it? This section examines the potential liabilities of insurance companies in a catastrophic earthquake and discusses the seriousness of them.

LOSSES TO INSURANCE COMPANIES FROM CATASTROPHIC EARTHQUAKES

The previous chapter described the total losses expected from great earthquakes. Insured losses are some fraction of those total losses that depends on the amount insured, the deductibles in place, and the amount of co-insurance. There are wide variations in the estimates of the losses to insurance companies from a catastrophic earthquake.

The most authoritative data on the potential losses to insurance companies under earthquake insurance coverage (only one of the insurance coverages that would be affected by an earthquake) comes from the California Department of Insurance, which for the last five years has compiled and published aggregate estimates of the "probable maximum loss" (PML) for insurance and reinsurance companies operating in California. The estimates assume a magnitude 8.25 earthquake in the San Francisco or Los Angeles areas and cover losses related to earthquake insurance coverage on building structures and contents.⁵⁵ The aggregate probable maximum losses for each zone in reporting years 1983, 1984, and 1985, are shown in the following table. (Reporting year 1985 covers insurance in 1984.)

INSURED LOSSES

[Millions of dollars]

	Reporting year		
	1983	1984	1985
A. San Francisco:			
Primary insurers:			
Residential	\$511	\$469	\$495
Commercial and other	1,644	974	1,576
Subtotal	2,155	1,443	2,071
Reinsurers (all classes)	1,789	1,938	2,197
Total	3,944	3,381	4,268
B. Los Angeles:			
Primary insurers:			
Residential	545	495	488
Commercial and other	2,332	1,515	2,525
Subtotal	2,877	2,010	3,013
Reinsurers (all classes)	2,606	2,650	2,922
Total	5,483	4,660	5,935

These figures are somewhat higher than the average insured losses (for earthquake insurance coverage on structures and content) but lower than the "worst case" damages.

Losses on earthquake insurance coverage on structures and contents, however, are only part of insurers earthquake liabilities. Losses under other coverages, such as workers compensation, fire, water damage, life, health, general liability, crime, and automobile, can be expected to contribute a great deal more. The California Department of Insurance has not estimated the losses under these types of coverage, and much less is known about them. The Department regards the above figures as

"firm minimum estimates of the insurance industry's total earthquake exposure in the event of a major earthquake."⁵⁶

Other groups have estimated insured losses under other types of insurance coverage for a catastrophic earthquake. An actuarial study performed for the American International Group (AIG) (an insurance organization that supports the creation of a Federal reinsurance corporation) made the following estimates of PML in 1986 for a repeat of the 1906 San Francisco Earthquake:⁵⁷

INSURED AND TOTAL LOSSES

[Millions of dollars]

Loss category	Total insured loss	Total loss
Direct damage.....	\$8,919.95	\$45,838.63
Fire and allied line.....	12,252.66	13,751.59
Workers compensation.....	617.50	617.50
Automobile physical damage.....	96.93	129.23
Life.....	617.50	617.50
Accident and health.....	43.23	43.23
All other ¹ damage.....	11,459.66	15,279.54
Total.....	34,007.43	76,277.22

¹ "Other" includes public property, bridges, utilities, etc.

These estimates are higher and based on less solid data than those by the California Department of Insurance. The "direct damage" part of these figures that correspond to the California Department of Insurance loss estimates are roughly twice as high. An earthquake engineer with extensive experience in insurance issues who reviewed the report believes the AIG figures overestimate the losses.⁵⁸

Some insurance companies, however, fear that potential losses could be still higher, due to several factors.⁵⁹ First, insurers expect additional losses under general liability coverage. Homeowners and businesses whose losses are not covered by insurance will likely seek compensation from negligent third parties. Injured workers who do not feel adequately compensated through workers compensation could also sue negligent third parties. Although there is uncertainty about how courts would determine liabilities after an earthquake, it is clear that businesses and governments could have substantial liabilities and that insurers could pay out substantial sums. Because earthquake hazards are to some extent foreseeable, and because there are reasonable actions that can be taken to protect against them, an "Act of God" defense may not be successful.⁶⁰ Because general liability insurance typically covers legal cost, insurers could pay out substantial sums whether or not lawsuits are successful.

Second, some fear that losses under fire insurance could be higher than predicted. Businesses and homeowners that are not insured for earthquakes are nearly always insured for fire. Although the extent of fire damage following an earthquake is highly uncertain, the potential exists for fire damage to exceed earthquake shaking damage and for losses under fire insurance to be several times the losses under earthquake insurance.

A third factor is that after a major earthquake, shortages of materials and labor would likely increase the costs and time required for rebuilding. These factors are not taken into consideration in the loss estimation methods.

Insurers would also be vulnerable in several other ways. If some insurers became insolvent after an earthquake, under state guarantee funds, "healthy" insurers would have to pay a portion of insolvent companies' claims. Insurers could also lose money on their investments and on other financial operations in an area struck by an earthquake. Similarly, insurers' investments may drop in value after an earthquake if many insurers seek to liquidated their investments at the same time to pay losses.

An example of the uncertainty that insurers face is illustrated by the "concurrent causation" doctrine in California. Court decisions there and elsewhere made, at least temporarily, insurance companies liable for essentially all residential earthquake damages. Most typical homeowners policies are "all-risk" policies that insure against all risks except as otherwise excluded, with earth movement (i.e. earthquakes) as one of the standard exclusions. Courts in California and several other states held that if a loss is due in part to two perils, one of which is excluded and one of which is not, the all-risk policy must pay the loss.⁶¹ The effect of this "concurrent causation" doctrine was that if any factor not excluded from the policy was found to have contributed to the damage, then the damage was covered by the policy. Since in almost all cases some factor other than the earthquake, such as negligence by the builder, could be found to contribute to the damage, insurance companies could almost always be made to pay for earthquake damages even when earthquake damage was specifically excluded from the policy. In effect, essentially all homeowners were insured for earthquakes without paying for the coverage.

A California law (Assembly Bill 2865) that took effect in 1985 was designed to reverse these court decisions. The law specified that if earthquake losses are excluded from an insurance policy, then earthquake losses from earthquakes are not compensable by insurance, even though other causes acted together with earthquakes to produce the loss.⁶² In addition, a key concurrent causation court case (*Garvey v. State Farm*) was reversed by the California Court of Appeals, making it much more difficult for homeowners to collect for earth movement damages when earth movement is excluded from an insurance policy. Insurance companies have also rewritten their forms to make it more difficult for the courts to interpret them in ways other than the way the insurance companies intended. These actions would seem to have eliminated the concurrent causation doctrine, at least for the time being.

Concurrent causation could have had a severe effect on the insurance industry. The California Department of Insurance estimated in 1984 that concurrent causation would have increased the probable maximum loss from \$3.9 billion to \$26.8 billion for the San Francisco earthquake and from \$5.5 billion to \$29 billion for the Los Angeles earthquake. Note that these figures are only for earthquake coverage, and do not

include fire, general liability, or earthquake losses under other lines of insurance.⁶³

Although the reversal of concurrent causation means that homeowners cannot collect from their insurance company as easily, they can still seek compensation from a third party. It is likely some of the losses that people can no longer recover under concurrent causation will show up under general liability coverage.

From the preceding discussion, it can be seen that there is a large range of possible losses to the insurance industry due to a catastrophic earthquake. It seems likely that the losses will be greater than the \$5 billion for just earthquake coverage estimated by the California Department of Insurance. It is difficult to judge the likelihood of the \$30 billion to greater than \$60 billion in insured losses estimated by some insurers.⁶⁴ The property damage from earthquakes and subsequent hazards are inherently somewhat uncertain, and these uncertainties are magnified when estimating losses to insurance companies. Estimating earthquake losses, and particularly insured losses, is a young science, and methods of estimating losses have not been standardized.⁶⁵

The size of possible losses becomes more speculative when one considers that a catastrophic earthquake might occur tomorrow or might not occur for 20 or 40 years. Changes in population, insurance practices and purchasing patterns, and in the siting and design of buildings could greatly change the insured losses. They could be much greater, due to population growth, or, if hazard reduction methods are effective, the same or less. Federal involvement in earthquake insurance would be likely to affect these factors and influence the size of the potential losses.

HOW SERIOUS ARE THESE LOSSES?

It is difficult to determine the effects of these potential earthquake losses on the insurance industry. In a general sense, these earthquake losses can be compared to indicators of the size of the industry. In 1985, the property and casualty industry received net premiums of \$144 billion, had a net investment income of \$19.5 billion, and an operating loss after taxes of \$3.3 billion.⁶⁶ The policyholders surplus, which is the sum left after the liabilities are deducted from assets and is the financial reserves that can be use for catastrophic losses, was \$75 billion.⁶⁷

The effect of a catastrophic earthquake on the reinsurance industry is of particular concern. In a major earthquake, over 70 percent of the insured structural losses is expected to be borne by the domestic and worldwide reinsurance market.⁶⁸ The reinsurance industry is small relative to the property-casualty industry and possibly especially vulnerable. In 1985, reinsurers reporting to the Reinsurance Association of America (RAA) (which includes most but not all reinsurers operating in the United States) reported net premiums of \$10.1 billion.⁶⁹ In addition, \$3.7 billion in premiums were believe to have been paid to unlicensed foreign reinsurers. The policyholders surplus of these reinsurers is in the \$7-8 billion range.⁷⁰ There is particular concern that "offshore" (i.e. outside of the United States) reinsurers, which are beyond U.S.

regulatory control may be unable or unwilling to meet all of their obligations following a catastrophic earthquake. To the extent that reinsurers do not meet their obligations, U.S. primary insurers will be hit much harder.

Comparing earthquake losses to these figures, it seems likely that an earthquake that caused \$5 billion in insured losses would have a noticeable but probably manageable effect on the insurance industry. Some insurers with particularly high earthquake exposure might be hard hit, but the industry as a whole could probably absorb the losses. A \$30 or \$60 billion loss, however, would have much more severe effects on individual companies and on the whole industry. One might expect insolvencies in the insurance industry, and might expect those companies that survived to be unable to meet society's demand for insurance.

Some people are also concerned that the combined effect of earthquakes on the insurance industry and other parts of the financial system would lead to wide disruptions of the financial system.⁷¹ The combination of insolvencies in the insurance industry, the liquidation of insurance company assets in order to pay claims, disruptions of the computer systems of financial institutions due to an earthquake, and defaults on mortgages due to uninsured damages could have a serious cumulative effect. Little work has been done to analyze the likelihood or consequence of each of these factors and it is difficult to assess the seriousness of a combination of them.

The seriousness of a major earthquake would also depend on its timing in relation to the underwriting cycle of the insurance industry. An earthquake would be particularly serious for the insurance industry in the "hard" part of the underwriting cycle when there is a capacity shortage in the industry (see discussion of the underwriting cycle in the previous chapter). Any additional unexpected losses, such as a catastrophic earthquake or other natural disaster, would exacerbate the capacity problem already compelling the industry to raise rates and reduce the availability of insurance.

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Chapter IV

OPTIONS TO ADDRESS DISASTER INSURANCE PROBLEMS

This chapter describes some options to improve disaster insurance and the major issues Congress faces in deciding among these options. It also identifies some areas where further information would be useful in making these choices.

PUBLIC GOALS FOR A DISASTER INSURANCE PROGRAM

Some societal goals for a disaster insurance program may be as follows:

- to reduce the sum of the total disaster costs to the Federal Government (i.e. disaster assistance costs, tax losses, and any losses from a Federal insurance or reinsurance program);
- to protect the insurance and financial system;
- to improve the incentives or reduce the disincentives for people to reduce earthquake damage;
- to leave individuals, companies, and communities in better shape after a disaster than under the current disaster recovery system;
- to minimize inefficiencies by reducing various overheads, payouts for spurious losses, etc;
- to make the system more equitable by treating people with similar losses and similar payments equally; and
- to increase the amount of choice that people have over the amount of protection they pay for and receive.

Because of the widely perceived inadequacies of the current system (described in chapter III) it may be possible to design a system that is better than the current system for each of these goals. But because these goals are to some extent in conflict (e.g. minimizing costs and maximizing post-disaster welfare), alternative proposals to address disaster insurance problems differ in their effect on each of these goals. Groups disagree about the priority of different goals and therefore differ in their support for different proposals.

In addition to these criteria that could be expected to be of general concern, other groups have other goals. Insurance companies are likely to be interested in proposals that produce the least risk for insurance companies and the greatest opportunities for profit and growth. Each segment of the insurance industry may support options that protect its interests relative to other segments of the industry. Insurance companies might also favor options that do not increase the potential for regulation. State insurance regulatory agencies might also be interested in protecting their authority relative to that of the Federal Government. The diversity of interests makes obtaining a consensus on a particular program difficult, even if there is a consensus that the current system can be improved upon.

OPTIONS

GENERAL OPTIONS

If Congress decides to attempt to treat disaster insurance problems, there are many possible options. The range of possible Federal actions is quite large, and most options have not been developed in detail. Some of the options are primarily intended to increase the number of people protected against financial loss from earthquakes; other options are to reduce the vulnerability of the insurance industry to earthquake losses. Among the options primarily intended to increase coverage are:⁷²

- to require properties purchased using federally backed or assisted mortgages to be insured against earthquake loss;

- to require banks backed by Federal insurance to protect their portfolios, through insurance or other means, against earthquake losses;

- to modify Federal disaster assistance to reduce disincentives against purchasing disaster insurance;

- to modify Federal disaster assistance to be more comprehensive and equitable so that earthquake insurance is not needed;

- to provide geologic and engineering information to insurance companies to help make insurance rates better correspond to the risk for specific buildings;

- to educate insurance consumers to help them make more informed decisions about purchasing earthquake insurance;

- to provide tax incentives for the purchase of earthquake insurance;

- to develop a Federal, multi-hazard, insurance coverage at rates that would be attractive to homeowners.

Among the options primarily intended to reduce the insurance industry's vulnerability are:

- to develop a Federal primary insurance program in which the Federal Government would bear the risk;

- to develop a Federal program of reinsurance, in which the Federal Government would in effect insure insurers or reinsurers;

- to develop a Federal program to loan money to insurers or reinsurers to meet obligations after a catastrophe;

- to modify IRS regulations or accounting practices to allow insurance companies to build tax-free reserves for rare catastrophes;

- to provide for enhanced Federal disaster relief in lieu of insurance for earthquakes that exceed the industry's capacity.

Proposals to address disaster insurance problems could make use of a combination of the above options. For example, an option that is intended to increase the purchase of earthquake insurance could be combined with an option to increase the industry's capability to provide for a catastrophe. Because there are many possible options and permutations of options, it is difficult to evaluate them all. Insurance industry groups have developed some of these possible options into specific legislative proposals, which are discussed below.

INSURANCE INDUSTRY PROPOSALS

Several different segments of the insurance industry have developed proposals to address disaster insurance problems. Industry efforts have intensified in the last year and industry groups have met repeatedly to try to forge a consensus. As of late 1986, the industry groups have moved closer together but have not yet reached a consensus. Because the proposals have been changing, the proposals described below do not necessarily indicate the current views of each organizations, but are presented here instead to illustrate proposals that incorporate some of the options described above.

One proposal was for a "Federal Earthquake Catastrophe Reinsurance Corporation."⁷³ This proposal was developed by the American International Group and has been advanced by the Reinsurance Association of America. It would establish a Federal tax-exempt corporation that would be an "excess reinsurer of last resort." Insurers or reinsurers would be able to purchase insurance in excess of amounts available from private sources. The corporation would sell reinsurance to insurers and reinsurers and would build up a tax-free catastrophe reserve with the premiums. If an earthquake occurred before the reserve had been built up to an adequate size, the corporation could borrow from the Treasury to meet its obligations. The Corporation would subsequently pay back the Treasury with future premiums.

Another proposal was developed by State Farm Insurance for a "Federal Disaster Insurance Fund Corporation (FDIFC)."⁷⁴ The program established by this proposal would cover insurance for earthquakes, volcanoes, floods, nuclear accidents, earth movement, and major hurricanes, all of which pose problems for insurers. The program would be essentially mandatory; everyone with property insurance would receive coverage for all of the hazards listed above and the FDIFC would be funded by a 2 percent charge on all major lines of property and casualty insurance. The FDIFC would also be authorized to borrow from the Treasury if the losses exceeded the funds it accumulated. The advantage of this approach is that it would cover many natural hazards and would thus spread the risks broadly; by covering hazards that threaten many geographic areas, many people would bear the costs of disasters and thus the premiums could be smaller. Under the proposed program, the insurance industry would write and market the insurance, and the FDIFC would reimburse insurers for losses and expenses. The program would primarily cover residential and small business insurance. There would be a maximum amount of insurance of \$500,000 for residential policies and \$1,000,000 for commercial policies. Higher coverages would be provided by the private industry, without Federal support, in the same way they are now.

The Alliance of American Insurers (AAI), a property-casualty trade association, has put forth a reinsurance proposal similar to that of the RAA/AIG proposal except that it would cover any catastrophe producing \$5 billion or more in insured property/casualty losses (except nuclear catastrophes).⁷⁵ A Government corporation would offer rein-

insurance for both primary carriers and reinsurers, and would accumulate a catastrophe reserve from the premiums.

The National Association of Independent Insurers (NAII), another property-casualty trade association, developed a proposal that distinguished between Class I and Class II earthquakes.⁷⁶ Class I earthquakes would be earthquakes for which damages are within the capability of the insurance industry to handle. Class II earthquakes would be earthquakes that would be so damaging as to be beyond the capability of the insurance industry to handle. Under the NAII proposal, the industry would handle Class I earthquakes with no need for Federal involvement. Class II earthquakes would be recognized as beyond the scope of the insurance industry, and the industry would "work with the Federal Government to develop a non-insurance means of mitigating the loss and damage" of this type of earthquake.⁷⁷ The dividing line between Class I and Class II earthquakes would depend on the financial condition of the insurance industry in terms of reserves and surpluses at the time of the disaster.

Before the RAA joined with the AIG in supporting the "Federal Earthquake Catastrophe Reinsurance Corporation" described above, the RAA developed a "Federal Catastrophe Loan Plan."⁷⁸ This plan would provide for a standby mechanism designed to come into effect only after a disaster of specified magnitude. Once triggered, the plan would make any company whose surplus was depleted by more than 25 percent be eligible for Federal loans for up to 95 percent of the loss beyond the 25 percent threshold. The insurance companies would pay back the loan at a rate of at least 5 percent of the principal per year, plus interest at rates "comparable to obligations of the United States having a similar maturity."⁷⁹ The agency administering the fund would have the power to defer or forgive repayment of all or parts of the loan or interest where necessary to prevent the insolvency of the insurer.

Although the industry has not yet reached a consensus on an approach, the ad hoc industry group working on disaster insurance issues reported in June 1986 that a consensus appeared possible with further work.⁸⁰ The earthquake insurance program outlined by the group was a combination of a primary program and an excess program. The primary program would be cover primarily one to four family residences while the excess program would be similar to that advanced by the RAA and AAI (described above).

ISSUES

Most of the proposals to address disaster insurance problems are combinations of a few basic themes. In deciding which, if any, of the various proposals to support, Congress may wish to consider several issues, including:

- Is there a need for Federal involvement in earthquake insurance beyond the current Federal programs of research (described in the appendix) and disaster assistance?

- If there is a need for Federal involvement, should the Federal Government be a primary insurer, a reinsurer, or both?

—Should a program cover only earthquakes or should it cover other hazards as well, and, if so, which ones?

—Should there be incentives (or requirements) to encourage the purchase of earthquake insurance and, if so, how strong should they be?

—To what extent, if any, should insurance be subsidized?

—Should disaster reparations (from either insurance or non-insurance sources) be made from a pre-paid fund or from loans?

—Should requirements to reduce earthquake hazards (such as building codes or land use regulations) accompany an earthquake insurance program?

These will be discussed below.

IS FEDERAL INVOLVEMENT NEEDED?

To ask whether Federal involvement is needed, one might ask if (1) the problems are serious enough to demand action; (2) if there are reasons why the private market, either in its current state or with minor modification, cannot adequately handle the problems; and (3) whether Federal rather than State action is appropriate.

Whether earthquake insurance problems are serious enough to warrant Federal action is a political as well as economic judgment. On the one hand, the rationale for Federal action is that there may be opportunities to: (1) prevent what could be unacceptable disruptions in the insurance and financial community; (2) replace parts of the current system of disaster assistance with an insurance-based system that could be more efficient and equitable; and (3) use insurance as a way to provide incentives for people to reduce their vulnerability to earthquakes, which in the long run could reduce the total costs of natural disasters to society.

On the other hand, a failure to act would not necessarily be catastrophic. Society has survived so far under the current system and while a catastrophic earthquake might occur tomorrow, it might not occur for decades. When it does occur: (1) the damages might not be as bad as the "probable maximum losses" identified by earthquake hazard studies (the losses could also be worse); (2) the losses are likely to be equivalent to only a small percentage of the total Federal budget and could be absorbed, if necessary, by the Federal Government; and (3) society might have changed in such a way as to make any Federal program created now inappropriate, inadequate, or unnecessary.

Whether action is desirable depends largely on a weighing of the potential benefit of making society more resilient to a catastrophic earthquake versus the effort needed to change the current system and the costs of the new system. These benefits and costs are both somewhat uncertain due to the uncertain nature of earthquake losses and the uncertainties in the costs of programs. The program costs could be low—many of the proposed new programs have been designed to be revenue-neutral—but the actual costs are unknown. While there is agreement that a catastrophic earthquake could cause significant problems with the current disaster assistance and insurance system, there is less agreement on what remedy, if any, is needed. The insurance trade or-

ganizations increasingly support some sort Federal involvement. A Federal Insurance Administrator ⁸¹ has indicated that he would support certain types of proposals to deal with the problem.⁸² The California State Department of Insurance believes that at the current low levels of earthquake coverage, it can prevent insurance companies from becoming insolvent due to an earthquake, but does not believe that it necessarily could if more policies were written.⁸³ It is also unclear if it could prevent insolvencies if the insured losses, due to earthquake losses under lines of insurance other than earthquake, were much greater than the \$5 billion listed in the Department's reports. Thus, while there is consensus that there are problems, there is no consensus on how to solve the problems.

A second question is whether these problems can be fixed by the private sector or whether a governmental program is needed. One view is that the problems should be the responsibility of the insurance industry. In this view, only the companies that imprudently underwrote bad risks would be insolvent in the event of a catastrophic earthquake. Companies that adequately assessed their risks and compared them to their reserves would likely survive. Accordingly, no action should be necessary to protect companies from a catastrophic earthquake.

People with opposing views raise several counter arguments. One is that major disruptions in the insurance industry are unacceptable to society regardless of who is at fault, and that a governmental role is warranted to prevent such disruptions. Another counter argument is that earthquake insurance problems come from government—the accounting and tax provisions that effectively prevent insurers from building reserves for rare catastrophies—and thus the solution must involve government. An option would be to modify these provisions to permit insurers to build catastrophe reserves, but this option would not increase the industry's catastrophe reserves immediately and the industry would still be vulnerable if a catastrophic earthquake occurred soon. Reinsurance—the other main mechanism for insurance companies to protect themselves against catastrophic losses—may also be inadequate because reinsurers may not be able to meet all of their obligations following a major earthquake.

Another argument is that without being able to build reserves, the actions insurers take to protect themselves from catastrophic loss, such as raising rates and deductibles, create other problems. This has already happened to some extent. The California Department of Insurance has worked to raise deductibles on residential insurance from 5 percent to 10 percent, and has told insurers that were overexposed to earthquake losses to offer less earthquake insurance.⁸⁴ While these actions reduce the exposure of insurance companies to earthquakes, they also make earthquake insurance a less attractive purchase.

If there is a need for government involvement in earthquake insurance, should it be a Federal or State involvement? The arguments for keeping governmental involvement in earthquake insurance confined to State governments include: (1) the regulation of insurance has traditionally been a State function in the United States (although this is

seen as anachronistic by some); (2) earthquakes and earthquake insurance are not major problems in some States, and those States might not support a Federal program; and (3) there may be a general desire to keep the Federal role to a minimum and to give the States as large a role as possible.

The arguments for Federal involvement include: (1) the Federal Government has an interest in reducing the payments under Federal disaster assistance and tax losses due to disasters; (2) the magnitude of losses in a catastrophic earthquake could overwhelm State resources and therefore could demand a Federal role; (3) catastrophic earthquakes could occur in several States and thus several States might need earthquake insurance programs; and (4) the insurance business is national and increasingly international in scope and operations. There could be options that would incorporate both a Federal and State role. For example, a reinsurance program could require a level of State reinsurance first, with the Federal Government providing reinsurance in excess of that the State could provide.

SHOULD THE FEDERAL GOVERNMENT BE AN INSURER, A REINSURER, OR BOTH?

If there is a Federal program, what kind of program should it be? The arguments in favor of having the Federal Government as the primary insurer include: (1) it would remove from industry those risks that seem undesirable; and (2) there would be a closer connection between the insurance and the regulatory authority of the Federal Government, allowing, if desired, the Government to use the insurance program to leverage improved earthquake hazard reduction activities, such as land use or building requirements. Some of the arguments for the Federal Government to be a reinsurer are that (1) it would involve a smaller Federal role; (2) it would make use of the available industry capacity; and (3) it would allow the industry to assume some of the risk in those parts of the market where it can operate profitably.

SHOULD A PROGRAM ADDRESS HAZARDS OTHER THAN EARTHQUAKES?

The main argument for covering only earthquakes is that earthquakes are the major threat to the insurance industry; no other natural hazard is likely to cause damages of the same magnitude. The argument for addressing several natural hazards simultaneously are: (1) other natural hazards are similar to earthquakes in that they are difficult to insure, people tend not to insure against them, and they are potentially costly to Federal disaster assistance programs; (2) under certain scenarios, such as direct hits by hurricanes on major cities, other hazards could have nearly as severe impacts on the insurance industry as earthquakes; (3) an insurance program that included many natural hazards could appeal to more people, which could help create a larger premium base, could help keep rates down, and might be more politically attractive; and (4) some hazards, such as flooding, are already covered by Federal programs and it could be desirable to have one integrated Federal natural hazard insurance program instead of separate programs for each hazard. If the primary rationale for a Federal program is to protect the

insurance industry from catastrophe, Federal involvement is most needed for earthquake insurance. If the concern is to increase the public's purchase of insurance for all hazards, then it might be desirable to have a program address other hazards.

SHOULD A PROGRAM BE PAID FOR BEFORE OR AFTER A DISASTER?

The advantage of a prepaid fund is that it would be a form of savings before the disaster and would put less burden on the budget after a disaster. A prepaid fund might also be politically more appealing; a loan after a disaster might be seen as a bailout of poorly managed companies. The disadvantage is that any fund that is established for one purpose might be used for another purpose. In that event, funds might not be available when needed. It may be difficult to determine how big a prepaid fund may be needed, and any prepaid fund might still need to be supplemented by loans after a disaster.

SHOULD EARTHQUAKE INSURANCE BE VOLUNTARY OR MANDATORY?

Should earthquake insurance for homeowners be completely voluntary or should there be strong incentives to encourage coverage? The argument in favor of keeping insurance completely voluntary is that homeowners should have the right not to purchase insurance if they do not want it or need it. Well-constructed wood frame homes are rarely damaged heavily in earthquakes and there is little earthquake risk in many parts of the country. The arguments in favor of strong incentives for purchasing earthquake insurance are that: (1) as described in chapter II, people do not adequately prepare for disasters; (2) there is a social benefit in having earthquake insurance because it lessens the need for disaster assistance; and (3) when more people are insured, insurance companies can get better "spread the risk," which may allow rates to be lower.

The issue is not one of simply requiring or not requiring earthquake insurance. There are a range of policy instruments, of varying strength, that could be used to encourage the purchase of earthquake insurance. Among these are requiring federally insured mortgages to be insured for earthquakes, or requiring banks to insure their portfolios against earthquake loss (this would encourage banks to require their borrowers to have earthquake insurance). Another option is to modify the current disaster assistance to reduce the disincentives to the purchase of insurance. The current policy is that disaster assistance recipients must buy insurance if reasonably available, but this only takes effect after a disaster has already struck. It could be made clear before a disaster that people who fail to buy reasonably available insurance would be ineligible for disaster assistance. The disadvantage to this is that it might be difficult to actually deny disaster assistance to victims after a disaster. Another option is to encourage the purchase of earthquake insurance through public education about earthquake hazards and the availability of insurance. The available research suggests, however, that although public education programs may be useful, well informed people do not necessarily buy insurance.

The choice of one of these alternatives may depend on one's views about how much earthquake insurance is essential. For society, it may not be necessary for everyone to be fully insured. As discussed previously, most wood-frame residences are not heavily damaged even in strong ground-shaking, and many people would be willing to self-insure at least low levels of damage. It is probably of greater societal concern to avoid defaults on loans, personal bankruptcies, the failure of financial institutions due to defaults on loans, and other rippling effects upon society. To prevent these failures, it might be desirable for people to have catastrophe insurance policies (ones with high deductibles that would not cover minor damage) and it might be desirable for financial institutions to protect their portfolios against earthquake losses.

SHOULD DISASTER INSURANCE BE SUBSIDIZED?

Under the present system of disaster assistance, taxpayers as a whole subsidize people harmed by disasters. This subsidization is not necessarily undesirable—there is a tradition of society helping those hurt by disasters and particularly those who could not afford insurance or less damage-prone dwellings. In another view, any subsidization is inequitable, penalizes those wise enough to avoid natural disasters, works as a disincentive for people to reduce hazards, and should be avoided.

SHOULD HAZARD REDUCTION REQUIREMENTS ACCOMPANY AN INSURANCE PROGRAM?

A major part of the NFIP, described in the Appendix, is the set of requirements designed to reduce construction in flood plains and thus reduce damages from floods. Should any earthquake insurance program contain analogous requirements for obtaining insurance on new construction in earthquake-prone areas? As described in chapter III, a major goal for an insurance program could be to increase the incentives for reducing earthquake losses, as reducing earthquake losses is what reduces the total costs to society. As was the case with the Flood Insurance Program, it may be expected that any land-use restrictions or building requirements will be met with opposition from local developers. It should be noted that because earthquakes and floods have different characteristics—floods occur in more narrowly defined areas, for example—the hazard reduction requirements for earthquakes would be quite different than those for floods.

CONCLUSIONS AND CONGRESSIONAL OPTIONS

The main themes from this report are that: (1) the effects of earthquakes on the insurance industry are worthy of serious concern; (2) the current disaster assistance system has widely recognized problems; (3) that options may exist that would both address both problems; but (4) that there is uncertainty about the extent of both problems and the desirability of particular options to fix the problems.

Congress may wish to consider either developing legislation to address these problems, or developing better information before deciding if legislation is warranted. Because there is a chance, of uncertain

likelihood, that an earthquake could cause widespread insolvencies in the insurance industry, it may be desirable at least to develop better information on the seriousness of losses to insurance companies. As described earlier, the California Department of Insurance has been developing some of this information, and some insurance companies have been closely examining their own potential losses, but there has been little analysis of the problems on a national level or by groups outside of the insurance industry.

Better information is also needed to evaluate the desirability of particular options. There is a need for better information on the costs of alternative proposals to the Federal Government, to insurers, and to policy holders, and there is a need to assess how these costs could change over the decades that a program would be in effect. Better information is also needed on how to design an earthquake insurance program to best encourage actions to reduce hazards. And better information is needed on the public acceptability of alternative proposals. How much would taxpayers and policyholders be willing to pay for increased disaster protection? Would strong incentives to encourage the purchase of disaster insurance be acceptable?

Some of the questions could be explored through hearings or workshops. Other information might require more analytic studies. Some information will remain uncertain: the extent of insured losses in a catastrophic earthquake will remain uncertain because they depend on the timing of the earthquake and on human actions following the earthquake.

Because earthquake insurance is unlikely to be viewed as an issue of national urgency except possibly following a catastrophic earthquake (or the prediction of one), it may be difficult to pass any legislation if there is significant opposition to it. A consensus or near consensus may be necessary for any proposal to be successful. There is not yet any consensus on earthquake insurance issues, and the issue has not yet been widely debated in public. Congress may wish to consider whether congressional hearings, workshops, or legislation could stimulate consensus building activities and move debates on earthquake insurance issues into a public forum.

APPENDIX

RELATED PROGRAMS

This appendix describes the current National Earthquake Hazards Reduction Program, the NFIP, and earthquake insurance programs in several other countries.

THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

PRINCIPAL AGENCIES

Since 1977, there has been a modest Federal program devoted to reducing earthquake hazards in the United States. In that year, Congress passed and the President signed the Earthquake Hazards Reduction Act, which established the National Earthquake Hazards Reduction Program. A number of the activities under the program are relevant to earthquake insurance. The program funds earthquake-related activities in the USGS, the NSF, the FEMA, and the NBS. The fiscal year 1986 authorization levels for each of the agencies under the program were:

National Earthquake Hazards Reduction Program Funding (thousands of dollars)

Agency	FY 86 authorization
FEMA	\$ 5,596
USGS	35,578
NSF	27,760
NBS	499

The program is intended to be a comprehensive Federal effort to reduce earthquake hazards that concentrates on the areas where the Federal Government has a clear role; the emphasis is on research that would be inefficient for the States or private industry to do and on developing educational materials and emergency management techniques in areas where it would be inefficient for each state to each do the same thing. FEMA, the agency with the clearest responsibility for increasing the safety of the populace from disasters, coordinates the program.

Elements of the program include:

Hazard delineation and assessment.—In this element the USGS studies the geology and seismicity of an area to identify and assess the seismic hazards. FEMA also conducts studies immediately following earthquakes to learn about the nature of the earthquake and the effectiveness of communities' earthquake preparations. The information generated by this element of the program serves as the basis for helping communities to prepare for earthquakes. This information is also useful to the insurance industry in setting rates and to homeowners in deciding whether to purchase earthquake insurance.

Earthquake Prediction Research.—In this element of the program, the USGS conducts research to understand how earthquakes occur and to identify precursors to earthquakes that would make it possible to predict earthquakes. The basic idea is that in the same way that sticks of wood make noises before they snap, so should the earth show some signs before an earthquake. As described in chapter II, earthquake prediction could save lives and prevent some property damage, but could also have a disruptive effect on earthquake insurance.

Seismic Design and Engineering Research.—Earthquakes would kill few people and cause relatively little damage if buildings were designed to withstand ground shaking. In this element, research is conducted to understand how buildings respond to earthquakes, how to design and construct buildings to resist earthquakes better, and how to transfer this knowledge to the engineers and architects who design buildings and develop building codes. An eventual effect of this research should be to exert downward pressure on earthquake insurance rates.

Preparedness Planning and Hazard Awareness.—This element focuses on the immediate problems of preparing communities for disaster. This includes improving Federal, State, and local planning and emergency response capabilities, improving public knowledge about earthquakes, and conducting research to understand better the various social, economic, legal, and political aspects of reducing earthquake hazards. An effect of these activities on earthquake insurance should be to help people make more informed decisions about earthquake insurance.

Fundamental Seismological Studies.—Under this element, the USGS and NSF conduct basic research necessary to understand the geologic processes that cause earthquakes. This work would be expected to affect earthquake insurance only indirectly through eventual increased understanding of earthquakes.

OTHER AGENCIES

A number of other agencies participate in earthquake activities in a variety of ways.⁸⁵ Many agencies participate in the Interagency Committee on Seismic Safety in Construction, which is developing standards for earthquake resistant design and construction in Federal facilities. The National Oceanic and Atmospheric Administration (NOAA) operates the tsunami warning network and issues tsunami warnings. The Department of Defense has sponsored seismological research and has supported seismographic networks in order to improve detection of underground nuclear tests. The Corps of Engineers has assessed the vulnerability of many dams to earthquakes. The Nuclear Regulatory Commission has sponsored seismographic networks in the eastern United States to help determine seismic risk at nuclear power plants and has also conducted engineering research related to improving the seismic resistance of nuclear power plants.

THE NATIONAL FLOOD INSURANCE PROGRAM

The NFIP is looked to as a possible model for a Federal earthquake insurance program, as it is a Federal program intended to address

insurance problems associated with a natural hazard. The NFIP is administered by the Federal Insurance Administration (FIA) to provide federally sponsored insurance in flood-prone areas.⁸⁶ In return for the insurance, which is subsidized, local communities that participate in the program must adopt certain land-use mechanisms designed to reduce the flood damage.

Prior to the National Flood Insurance Act of 1968 that established the program, private insurance for floods had not been generally available. The insurance was unattractive for private insurers for reasons similar to those that earthquake insurance is unattractive, namely, that there is the potential for catastrophes and adverse selection. In addition, the insurance companies did not have the capability to develop the detailed and accurate flood hazard maps that would allow them to assess risks and set rates.

The NFIP has been modified in response to legislation in several ways. The role of the Federal Government with respect to the insurance industry, the incentives for local land-use control, and the types of dwellings and businesses covered have all changed. As originally set up, both the Federal Government and the insurance industry each had a risk-bearing role. In 1978, the program was changed to eliminate private insurance company involvement. The program was later changed again to reinvolve private sector insurance companies. Private insurance companies now market and service flood insurance policies under rules and regulations issued by the Federal Insurance Administrator. The FIA is still responsible for: (1) determining rates, coverage limits and eligibility; (2) establishing flood plain management ordinances; and (3) providing the financial backup for the program.⁸⁷

In 1973, the NFIP was modified (the Flood Disaster Protection Act, Public Law 93-234) to strengthen incentives for communities to join the program. If communities did not join the program within a specified time period, property owners could not purchase the federally subsidized flood insurance and would not be eligible for disaster relief after a flood. In communities that did not join the program, property owners in flood hazard areas could not obtain Federal loans or federally assisted or guaranteed loans for new construction or for mortgages on existing buildings. A 1977 modification, contained in title VII of the Housing and Community Development Act of 1977 (Public Law 95-128) removed this last sanction, and allowed federally insured or regulated private lending institutions to make loans to property owners in flood hazard areas after notifying loan recipients that they are not eligible for Federal disaster relief in the event of a flood.

The program was originally available only for one- to four-family homes and small business firms, but was later expanded to include other types of residences and businesses.

The NFIP has often been controversial. Some have argued that the land use controls have not been strong enough, particularly in coastal areas, and that the Government-subsidized insurance has subsidized development in flood-prone areas, creating the potential for larger disasters. NFIP has also been criticized by developers for being too restric-

tive, and by others for being too expensive. The program is still evolving, and, according to the FIA, becoming more successful over time. In recent years the FIA has actively sought to reduce the degree of subsidization.

Is the NFIP a good model for earthquakes? Compared to earthquakes, floods are similar but not identical in their characteristics that affect insurance. Both have the potential for catastrophic loss and for adverse selection, but with floods, adverse selection is the dominant concern while for earthquakes the potential for catastrophe is the dominant concern. This suggests that some type of reserving mechanism may be more important for earthquakes than for floods. The NFIP also contains several lessons for a potential earthquake program. Like flood insurance, an earthquake program that is perceived to subsidize earthquake insurance and thus earthquake damage may be seen as encouraging unsound land-use and building design. On the other hand, the flood insurance program also demonstrates the potential of the Federal Government to stimulate hazard-reduction activities, and demonstrates how those actions can be controversial.

EARTHQUAKE INSURANCE IN OTHER COUNTRIES

JAPAN

Japan has separate systems for residential and industrial earthquake insurance.⁸⁸ Individual companies write residential earthquake insurance, either as part of a comprehensive policy or as an addition to fire policies. It is not mandatory. The earthquake insurance does not provide complete coverage. It does not cover losses that are less than 50% of the sum insured, and provides coverage equal to only 30 to 50 percent of the total amount insured.⁸⁹ The earthquake coverage also covers related losses such as fire following earthquake, volcanic eruptions, or tsunamis. Companies writing residential earthquake insurance participate in the Japan Earthquake Reinsurance Company (JERC) which pools funds from participating companies and creates a large earthquake reserve. The JERC is then reinsured by the Japanese government.

Japanese industrial commercial insurance and reinsurance is handled by the private commercial market. Because of a high concentration of value and a limited capacity of Japanese insurance companies, the commercial insurance market in Japan is somewhat restricted, and insurance policies pay only part of the total damage.⁹⁰

NEW ZEALAND

Earthquake insurance in New Zealand evolved out of a War Damage Insurance System set up in 1941. Because few war damage claims were made against the fund, coverage was broadened in 1944 to include shaking and fire resulting from earthquakes.⁹¹ Under this system, all properties with fire insurance are automatically covered for earthquakes. The Earthquake and War Damage Commission manages the fund that pays earthquake claims. The fund is financed by charging insurance companies about 1 percent of the fire insurance. Deductibles range

from 1 percent to 25 percent. The Commission has had favorable claims experience so far because of little earthquake activity.

MEXICO

Earthquake insurance in Mexico was developed and is operated by the private sector.⁹² The national government regulates the practice to prevent insurers from over-extending their underwritings and thus to preserve the insurers' financial integrity. Earthquake insurance is written as an endorsement to the basic fire policy. There is a mandatory 2 percent deductible and a "Full Proportion Clause" which means that all of the value of a dwelling must be insured if the insurer is to pay all of any damage. Little residential earthquake insurance is written, except where required as a condition for a loan. Some mortgage companies require such coverage.

Only about 10 percent of the total economic loss of \$5 to \$10 billion in the 1985 Mexico City earthquake is thought to have been insured.⁹³ Most of this insured loss was thought to have been borne by international companies. The low percentage of loss is due to the fact that many private and governmental buildings were uninsured, and that many of those that were insured were underinsured as insured values had not kept up with inflation and the devaluation of the peso. The combination of a low percentage of insured losses and the fact that the losses were spread internationally prevented the earthquake from being catastrophic to insurers. It should be noted that the Mexico City losses are much smaller than those expected in a major Californian earthquake.

COLOMBIA

Earthquake insurance in Colombia is mandatory for real estate belonging to banks, insurance companies, and financial institutions, as well as for all mortgaged properties. The property must be insured at 100 percent of its actual cash value, there is a deductible of 2 percent, and the insured pay 20 percent of the net loss after the deductible.

ENDNOTES

¹ Prepared by David W. Cheney, Analyst in Science and Technology, Science Policy Research Division.

² Statement of Jeffrey S. Bragg, Administrator, Federal Insurance Administration, in U.S. Congress, Senate, Committee on Commerce, Science, and Transportation, Subcommittee on Science, Technology and Space, Earthquake in Mexico, Hearings, 99th Cong. 1st Sess. October 3, 1985, Washington, U.S. Govt. Print. Off. 1986, p. 76.

³ Schnell, Mary L. and Darrell G. Herd, eds. National Earthquake Hazards Reduction Program: Overview. Report to the United States Congress, Alexandria VA, U.S. Geological Survey Circular 918, 1983, p. 16.

⁴ Scawthorn, Charles. Fire Following Earthquake. Paper presented at First International Symposium on Fire Safety Science, Gaithersburg, MD, National Bureau of Standards, October 7-11, 1985.

⁵ Table taken from information in California Department of Insurance, California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An Estimate of Potential Insured Losses From Analysis of Data Submitted by Property and Casualty Companies in California, June 1985, p. 6-9. The figures in the table are not exactly the

percentage of loss for each building class; they have been adjusted so they will yield the correct loss to insurers when deductibles have been subtracted.

⁶ Many of these methods are reviewed in: Reitherman, Robert M. A Review of Earthquake Damage Estimation Methods. *Earthquake Spectra*, v. 1, no. 4, August, 1985, p. 805-847.

⁷ Federal Emergency Management Agency. An Assessment of the Consequences and Preparations for a Catastrophic California Earthquake: Findings and Actions Taken. Washington, November 1980, p. 22.

⁸ Steinbrugge, Karl V. Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards. New York, Skandia America Group, 1982, p. 191.

⁹ Steinbrugge, Karl V., S.T. Algermissen, Henry J. Lagorio, Lloyd S. Cluff, and Henry J. Degenkolb. Metropolitan San Francisco and Los Angeles Earthquake Loss Studies: 1980 Assessment. Denver, Colorado, U.S. Geological Survey. Open-File Report 81-113, 1981. Table 26. These studies were updates of studies done in 1972 and 1973 for the National Oceanic and Atmospheric Administration.

¹⁰ *Ibid.*, p. 23.

¹¹ Central United States Earthquake Preparedness Project (CUSEPP). An Assessment of Damage and Casualties for Six Cities in the Central United States Resulting from Two Earthquakes, $M=7.6$ and $M=8.6$, in the New Madrid Seismic Zone. Draft Report intended for planning purposes sponsored by the Federal Emergency Management Agency, 1985. No pagination.

¹² Hays, W. W., ed. Facing Geologic and Hydrologic Hazards. Earth-Science Considerations. U.S. Geological Survey Professional Paper 1240-B. Washington, U.S. Govt. Print. Off., 1981, p. B103.

¹³ Petak, William J. and Arthur A. Atkisson. Natural Hazard Losses in the United States: A Public Problem. *Policy Studies Review*, v. 4, May 1985, p. 662-669.

¹⁴ Personal Communication with Darrell Herd, U.S. Geological Survey, December 1985.

¹⁵ Kerr, Richard A. Earthquake Forecast Endorsed. *Science*, April 19, 1985, p. 311.

¹⁶ Hays, W. W., ed. Facing Geologic and Hydrologic Hazards. Earth-Science Considerations. U.S. Geological Survey Professional Paper 1240-B. Washington, U.S. Govt. Print. Off., 1981, p. B103. Loss estimates may be high or low by a factor of two.

¹⁷ U.S. Department of the Interior, Geological Survey. Recent U.S. and Colombian Landslides Illustrate World-Wide Problem. Press Release. April 25, 1986.

¹⁸ W.W. Hays, ed. Facing Geologic and Hydrologic Hazards: Earth-Science Considerations. Geological Survey Professional Paper 1240-B. Washington, DC, U.S. Government Printing Office, 1981, p. B66.

¹⁹ *Ibid.*

²⁰ For example, the 1985 version of State Farm Insurance's proposal for a Federal Disaster Insurance Fund Corporation covered non-seismic earth movement.

²¹ Bolt, B.A., W.L. Horn, G.A. MacDonald, and R.F. Scott. Geological Hazards: Earthquakes—Tsunamis—Volcanoes—Avalanches—Landslides—Floods. New York, Springer-Verlag, 1975, p. 63.

²² Tilling, Robert I. Eruptions of Mount St. Helens: Past, Present, and Future. Washington, U.S. Govt. Print. Off. No date given.

²³ Information provided by State Farm Insurance, 1985.

²⁴ Petak, William J., and Arthur A. Atkisson. Natural Hazard Losses in the United States: A Public Problem. *Policy Studies Review*, v. 4, May 1985, p. 662-669.

²⁵ *Ibid.*

²⁶ Much of the material in this section is from: U.S. Library of Congress, Congressional Research Service. Property-Casualty Insurance Market Operation. Report No. 85-629 E, by David Whiteman, March 20, 1985. Washington, 1985, 10 p.

²⁷ To some "risk" more precisely is a combination of the probability and the magnitude of some loss. One can reduce a risk by reducing either the probability or the magnitude of the loss.

²⁸ The two sides of the insurance business are not neatly divided. For example, some health insurance can be written by casualty companies.

²⁹ Insurance Information Institute. 1986-87 Property/Casualty Fact Book. New York. 1986. Inside front cover.

³⁰ California Department of Insurance. California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An estimate of Potential Insured Earthquake Losses From Analysis of Data Submitted by Property and Casualty Companies in California. June 1985. p. 16.

³¹ Material in this section comes from Anderson, Dan, William J. Petak, and Carl E. Widell. Earthquake Insurance Practices. Technical Report No. 1388-2 prepared for the Federal Insurance Administration by the J.H. Wiggins Company. Washington. June 1981. p. II-12.

³² Ibid. p. II-19.

³³ Ibid. p. II-20.

³⁴ Ibid., p. II-4.

³⁵ Steinbrugge, Karl V. Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards. New York, Skandia America Group. 1982. p. 189.

³⁶ Ibid., p. 192.

³⁷ California Department of Insurance. California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An Estimate of Potential Insured Losses From Analysis of Data Submitted by Property and Casualty Companies in California. June 1985. p. 16.

³⁸ Steinbrugge, Karl V. Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards. New York, Skandia International Group. 1982. p. 197.

³⁹ Ibid. p. 197.

⁴⁰ California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An Estimate of Potential Insured Earthquake Losses From Analysis of Data Submitted by Property and Casualty Companies in California. California Department of Insurance. June 1985. pp. 13.

⁴¹ Ibid. p. 13.

⁴² California Earthquake Zoning and Probable Maximum Loss Report. p. 13.

⁴³ Anderson, Dan, William J. Petak, and Carl E. Widell. Earthquake Insurance Practices. Technical Report No. 1388-2, Prepared for the Federal Insurance Administration. June 1981. p. II-24.

⁴⁴ Hudson, James M., Carl E. Widell, and William J. Petak. Appendix J. Earthquake Insurance Survey: Data Analysis and Results. in Anderson, Dan, William J. Petak, and Carl E. Widell. Earthquake Insurance Practices. Technical Report No. 1388-2 prepared for the Federal Insurance Administration. June 1981. p. J-2 to J-10.

⁴⁵ Kunreuther, Howard, Ralph Ginsberg, Louis Miller, Philip Sagi, Paul Slovic, Bradley Korkan, and Norman Katz. Disaster Insurance Protection: Public Policy Lessons. New York. John Wiley & Sons. 1978.

⁴⁶ Author's conversations with several Californian structural engineers.

⁴⁷ Program Guide: Disaster Assistance Programs. (no author given) Washington, D.C., U.S. Govt. Print. Off. October 1984. p. 1. Regulations governing disaster assistance are contained in 44 C.F.R. 200 and 205.

⁴⁸ Program Guide: Disaster Assistance Programs, p. 7-8; 44 C.F.R. 200 and 205; and 13 C.F.R. 123.

⁴⁹ Ibid., pp. 9-12.

⁵⁰ For example, the Southeast Hurricane Disaster Relief Act permitted the Small Business Administration (SBA) to forgive up to \$1800 of each loan, and the Congress permitted the SBA to forgive the first \$5000 of loans after Hurricane Agnes. U.S. General Accounting Office. Federal Disaster Assistance: What Should the Policy Be?: Report to the Chairman and Ranking Minority Member Senate Committee on the Budget, U.S. Senate by the Comptroller General of the United States. PAD 80-39. Washington, 1980. p.7.

⁵¹ 13 C.F.R. 123. Also, Program Guide: Disaster Assistance Programs, p. 14.

⁵² U.S. General Accounting Office. Federal Disaster Assistance: What Should the Policy Be?: Report to the Chairman and Ranking Minority Member Senate Committee on the Budget, U.S. Senate by the Comptroller General of the United States. PAD 80-39. Washington, 1980. 65 pp.

⁵³ Personal communication with John Wiggins, 12/11/85.

⁵⁴ Personal interview with Henry J. Degenkolb of H.J. Degenkolb and Associates, December 19, 1985.

⁵⁵ California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An Estimate of Potential Insured Earthquake Losses From Analysis of Data Submitted by Property and Casualty Companies in California. California Department of Insurance, June 1986. p. 1.

⁵⁶ *Ibid.*, p. 3.

⁵⁷ American International Group, Inc. Update of Actuarial Study Regarding Federal Earthquake Reinsurance Plan. September, 1985. Analysis performed by Tillinghast, Nelson & Warren, Inc.

⁵⁸ John Wiggins, personal communication, June 23, 1986.

⁵⁹ Personal communication with George H. Ramsdell and Don G. Friedman, The Travelers, November 1986.

⁶⁰ Association of Bay Area Governments. The Liability of Businesses and Industries for Earthquake Hazards and Losses: Executive Summary. Oakland, CA, 1984 (no pagination). Also, Margerum, Terry. Earthquake Hazards and Local Government Liability: Executive Summary. Association of Bay Area Governments, Oakland (no date or pagination).

⁶¹ California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An Estimate of Potential Insured Earthquake Losses From Analysis of Data Submitted by Property and Casualty Companies in California. California Department of Insurance, May 1984. pp. 22-23.

⁶² California Earthquake Zoning and Probable Maximum Loss Evaluation Program, June 1985. p. 12.

⁶³ *Ibid.* p. 22-23.

⁶⁴ Some believe that the aggregate industry exposure could be close to the industry's policyholders surplus, which is around \$80 billion, including reinsurance. Letter from George H. Ramsdell, Jr., The Travelers Insurance Companies, September 23, 1986.

⁶⁵ A panel of the National Academy of Science's Committee on Earthquake Engineering has been examining earthquake loss methodologies—a contentious subject within the engineering community—but this panel has not examined methods of estimating total insured losses.

⁶⁶ Insurance Information Institute. 1986-87 Property/Casualty Fact Book. New York, 1986. Inside front cover.

⁶⁷ *Ibid.*

⁶⁸ California Earthquake Zoning and Probable Maximum Loss Evaluation Program: An Estimate of Potential Insured Earthquake Losses From Analysis of Data Submitted by Property and Casualty Companies in California. California Department of Insurance, June 1986. p. 3.

⁶⁹ Reinsurance Association of America. Reinsurance Underwriting Review. Washington, 1986. p. 4 and 6.

⁷⁰ Letter from George Ramsdell, The Travelers Insurance Companies, September 23, 1986.

⁷¹ Statement of Jerry Haber, National Technical Systems, in U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. Earthquake in Mexico. Hearing. 99th Cong., 1st Sess., October 3, 1985. Washington. U.S. Govt. Print. Off. 1986. p. 77-83.

⁷² Many of these options are listed in: Atkisson, Arthur A. and William J. Petak. Earthquake Insurance: A Public Policy Analysis. Technical Report No. 1388-4 prepared for the Federal Insurance Administration. Washington, Federal Emergency Management Agency. June 1981. p. IV-1 to IV-52.

⁷³ Reinsurance Association of America and American International Group, Inc. Background Information on the Federal Earthquake Catastrophe Reinsurance Corporation. Unpublished. May 29, 1985. 19 p.

⁷⁴ State Farm Insurance. Federal Disaster Insurance Fund Corporation (FDIC): Proposed. 1985. Unpublished document.

⁷⁵ Alliance of American Insurers. Proposal for a Federal Catastrophe Reinsurance Corporation. Schaumburg, IL. November 1985. 4 p.

⁷⁶ Based on information provided by C. Robert Hall, Vice President, National Association of Independent Insurers. September 17, 1985.

⁷⁷ Ibid.

⁷⁸ Reinsurance Association of America. Background Information and Summary of the Federal Catastrophe Loan Plan. May 16, 1980. Appendix F. in Anderson, Dan, William J. Petak, and Carl E. Widell. Earthquake Insurance Practices. Technical Report No. 1388-2. Washington, Federal Emergency Management Agency. June 1981. p. F-2 to F-26.

⁷⁹ Ibid. p. F-7.

⁸⁰ The Report of the Ad Hoc Industry Group on Earthquake and Related Disaster Insurance Issues. Unpublished paper. June 11, 1986. 9 p.

⁸¹ Administrator of the Federal Insurance Administration, an agency under the aegis of the Federal Emergency Management Agency that administers separate property insurance programs for flood insurance.

⁸² Statement of Jeffrey S. Bragg, Administrator, Federal Insurance Administration, Federal Emergency Management Agency. In: U.S. Congress. Senate. Committee on Commerce, Science, and Transportation. Subcommittee on Science, Technology, and Space. Earthquake in Mexico. Hearing. 99th Cong., 1st Sess. October 3, 1985. Washington, U.S. Govt. Print. Off. 1985. p. 74-77.

⁸³ Richard J. Roth. Assistant Insurance Commissioner, State of California Department of Insurance. Personal interview. December 27, 1985.

⁸⁴ Richard J. Roth, Assistant Insurance Commissioner, California Department of Insurance. Personal interview, December 27, 1985.

⁸⁵ Schnell, Mary L. and Darrell G. Herd, ed. National Earthquake Hazards Reduction Program: Fiscal 1983 Activities. Alexandria, VA, U.S. Geological Survey, Circular 919. p. 49-60.

⁸⁶ Sources for this section: U.S. Library of Congress. Congressional Research Service. Federal Insurance Administration (FIA) Programs for Flood and Crime Insurance and Riot Reinsurance. Issue Brief no. MB84208, by David Whiteman. Oct. 30, 1984. Washington, 1984. p. 2-4. Also: League of Women Voters. The National Flood Insurance Program: Is it Working? Pub. No. 640. Washington, 1982. 6 p.

⁸⁷ Federal Insurance Administration. The National Flood Insurance "Write Your Own" Program: Executive Prospectus. Washington, 1984. p. 3.

⁸⁸ Anderson, Dan, William J. Petak, and Carl E. Widell. Earthquake Insurance Practices. Report prepared by the J.H. Wiggins Company for the Federal Insurance Administration. June 1981. pp. IV-3 to IV-8.

⁸⁹ Based on information provided by Jack Quinn of Arnold and Porter, representing State Farm, December 1985.

⁹⁰ Anderson, Petak, and Widell. Earthquake Insurance Practices. pp. IV-3 to IV-8.

⁹¹ Ibid. pp. IV-12 to IV-13.

⁹² Ibid. pp. IV-14 to IV-15.

⁹³ Reinsurance Offices Association. The 1985 Mexico Earthquake. London, U.K., 1986. p. 25-27.